US006125186A

United States Patent [19]

Saito et al.

[11] Patent Number: 6,125,186

[45] Date of Patent: *Sep. 26, 2000

[54] ENCRYPTION COMMUNICATION SYSTEM USING AN AGENT AND A STORAGE MEDIUM FOR STORING THAT AGENT

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[73] Assignee: Fujitsu Limited, Kawasaki, Japan

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: 08/893,546

[22] Filed: Jul. 8, 1997

[30] Foreign Application Priority Data

Nov. 28, 1996 [JP] Japan 8-317505

[51] Int. Cl.[7] H04K 1/02

[52] U.S. Cl. 380/287; 380/260; 380/274; 380/27; 713/200; 713/150

[58] Field of Search 380/48, 27, 9, 380/23, 25, 49, 274, 260, 287; 713/200, 150

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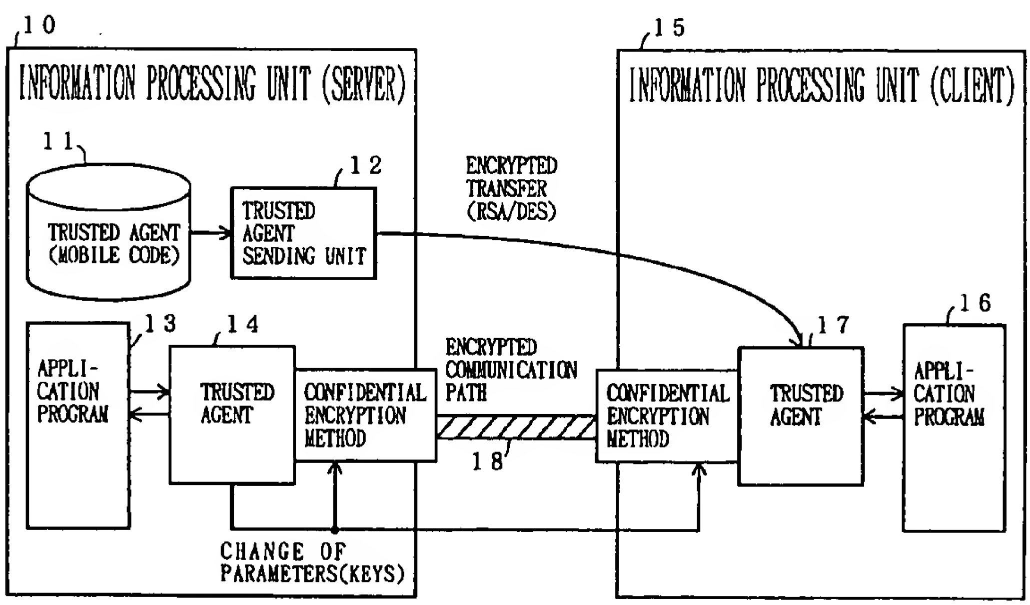
Primary Examiner—Tod R. Swann
Assistant Examiner—Paul E. Callahan
Attorney, Agent, or Firm—Staas & Halsey, LLP

[57] ABSTRACT

An agent is permanently resident in a server as software for the purpose of cryptographic processing. In addition, another agent that is described in mobile code and contains a program for the purpose of cryptographic processing is also stored in the server. When data that are to be sent and received between the server and a client are encrypted, the agent that is described in mobile code is sent from the server to the client. When the client receives data that were encrypted in the server, it reproduces those data by decryption using the received agent.

18 Claims, 29 Drawing Sheets



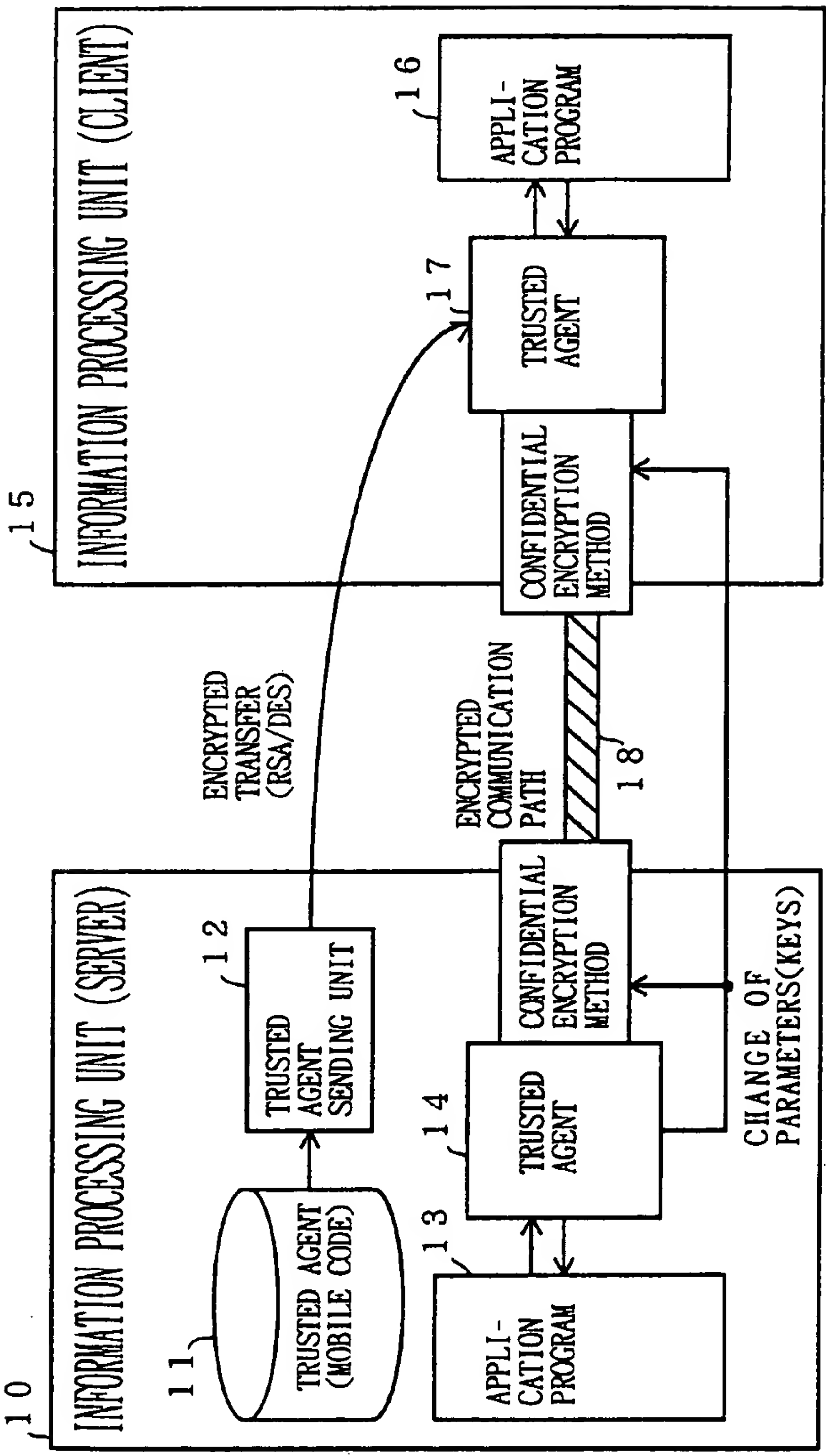

15
INFORMATION PROCESSING UNIT (CLIENT)
16
APPLI-CATION PROGRAM
17
TRUSTED AGENT
CONFIDENTIAL ENCRYPTION METHOD
ENCRYPTED TRANSFER (RSA/DES)
ENCRYPTED COMMUNICATION PATH
18
10
INFORMATION PROCESSING UNIT (SERVER)
11
TRUSTED AGENT (MOBILE CODE)
12
TRUSTED AGENT SENDING UNIT
13
APPLI-CATION PROGRAM
14
TRUSTED AGENT
CONFIDENTIAL ENCRYPTION METHOD
CHANGE OF PARAMETERS(KEYS)

FIG. 1

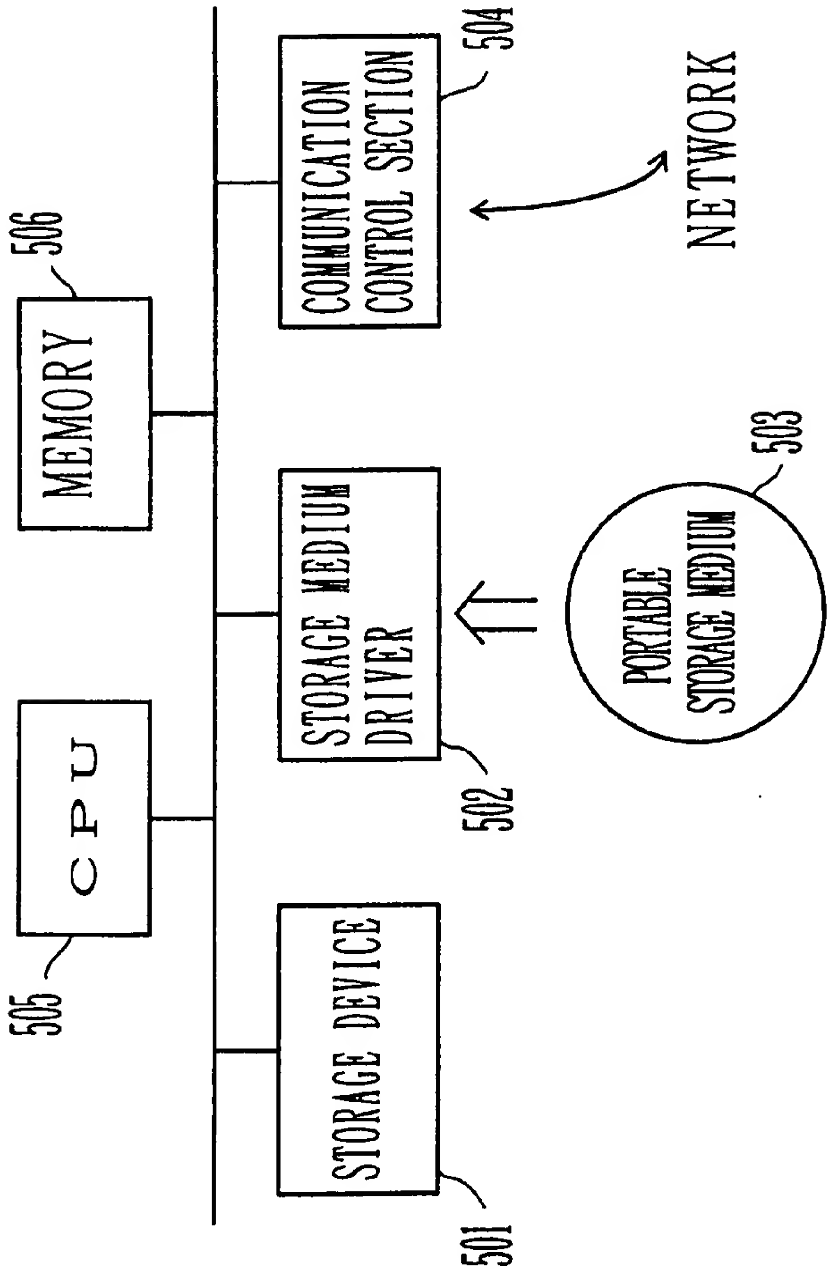

MEMORY
506
CPU
505
COMMUNICATION CONTROL SECTION
504
NETWORK
STORAGE MEDIUM DRIVER
502
PORTABLE STORAGE MEDIUM
503
STORAGE DEVICE
501

FIG. 2

FIG. 3A

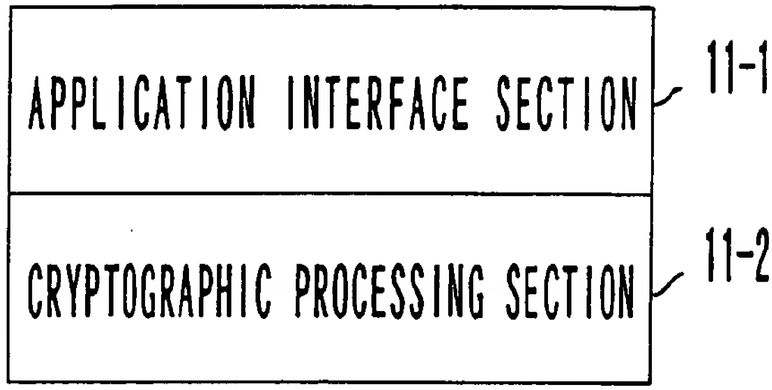
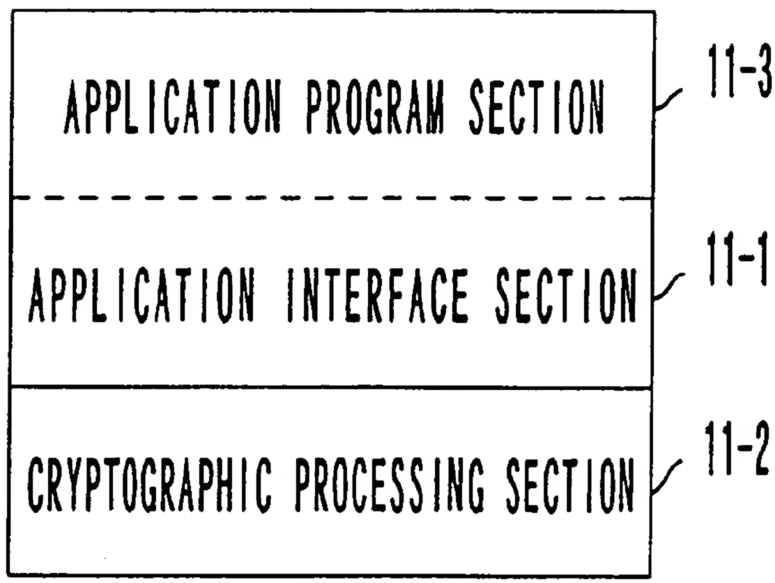

APPLICATION INTERFACE SECTION
11-1
CRYPTOGRAPHIC PROCESSING SECTION
11-2

FIG. 3B


APPLICATION PROGRAM SECTION
11-3
APPLICATION INTERFACE SECTION
11-1
CRYPTOGRAPHIC PROCESSING SECTION
11-2

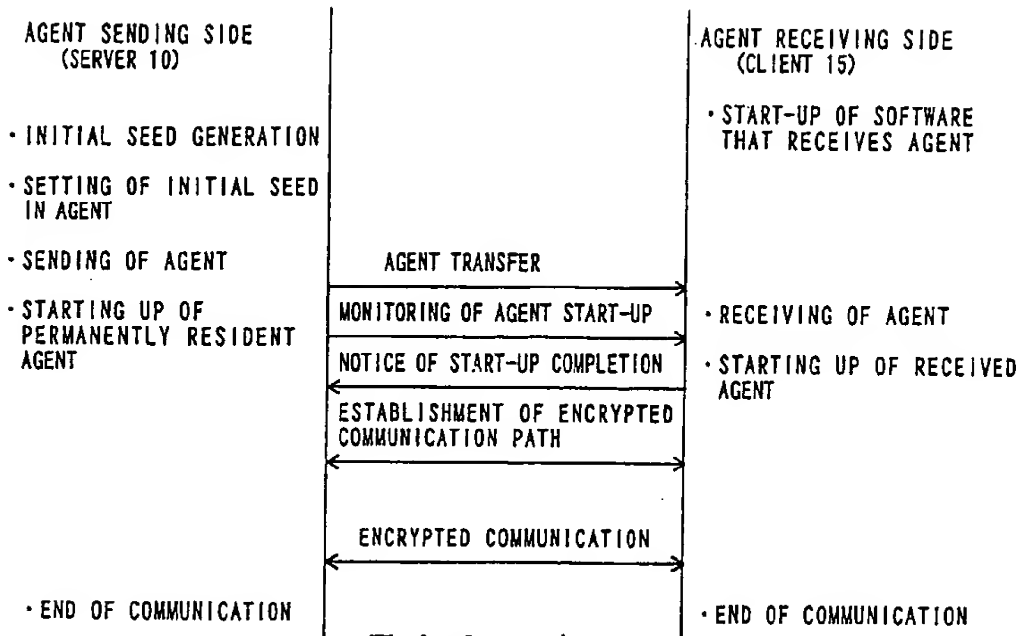

AGENT SENDING SIDE
(SERVER 10)
AGENT RECEIVING SIDE
(CLIENT 15)
· START-UP OF SOFTWARE THAT RECEIVES AGENT
· INITIAL SEED GENERATION
· SETTING OF INITIAL SEED IN AGENT
· SENDING OF AGENT
AGENT TRANSFER
· STARTING UP OF PERMANENTLY RESIDENT AGENT
MONITORING OF AGENT START-UP
· RECEIVING OF AGENT
NOTICE OF START-UP COMPLETION
· STARTING UP OF RECEIVED AGENT
ESTABLISHMENT OF ENCRYPTED COMMUNICATION PATH
ENCRYPTED COMMUNICATION
· END OF COMMUNICATION
· END OF COMMUNICATION

FIG. 4A

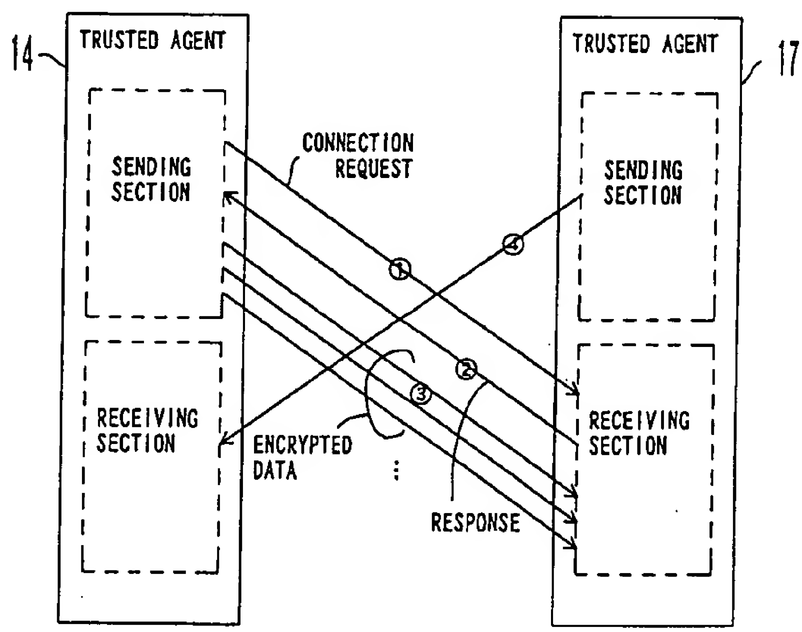

14
TRUSTED AGENT
TRUSTED AGENT
17
SENDING SECTION
CONNECTION REQUEST
SENDING SECTION
1
4
2
3
RECEIVING SECTION
ENCRYPTED DATA
RECEIVING SECTION
RESPONSE

FIG. 4B

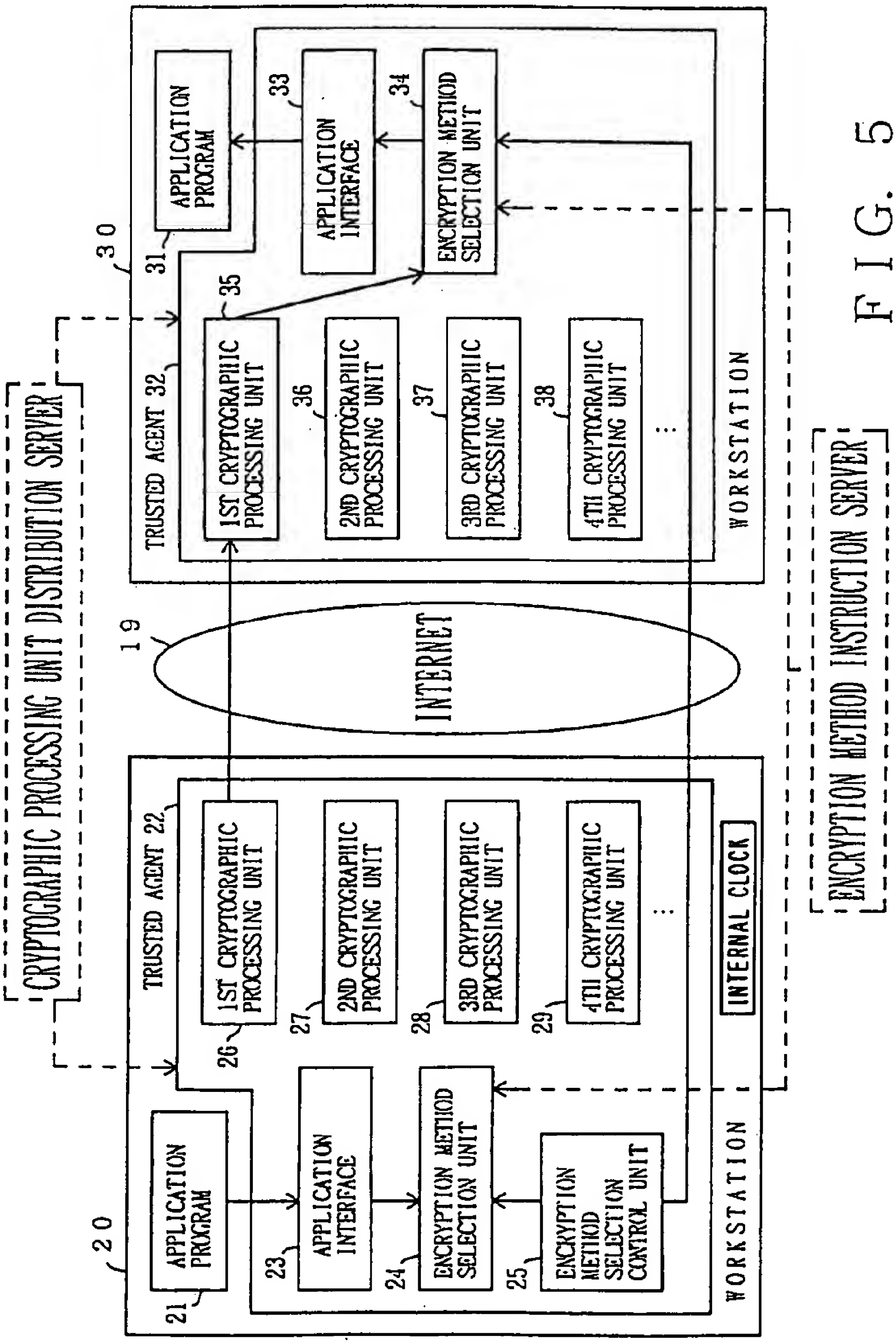

CRYPTOGRAPHIC PROCESSING UNIT DISTRIBUTION SERVER
ENCRYPTION METHOD INSTRUCTION SERVER
INTERNET
19
20
30
WORKSTATION
WORKSTATION
TRUSTED AGENT 22
TRUSTED AGENT 32
APPLICATION PROGRAM
APPLICATION INTERFACE
ENCRYPTION METHOD SELECTION UNIT
ENCRYPTION METHOD SELECTION CONTROL UNIT
1ST CRYPTOGRAPHIC PROCESSING UNIT
2ND CRYPTOGRAPHIC PROCESSING UNIT
3RD CRYPTOGRAPHIC PROCESSING UNIT
4TH CRYPTOGRAPHIC PROCESSING UNIT
INTERNAL CLOCK
21
23
24
25
26
27
28
29
31
33
34
35
36
37
38

FIG. 5

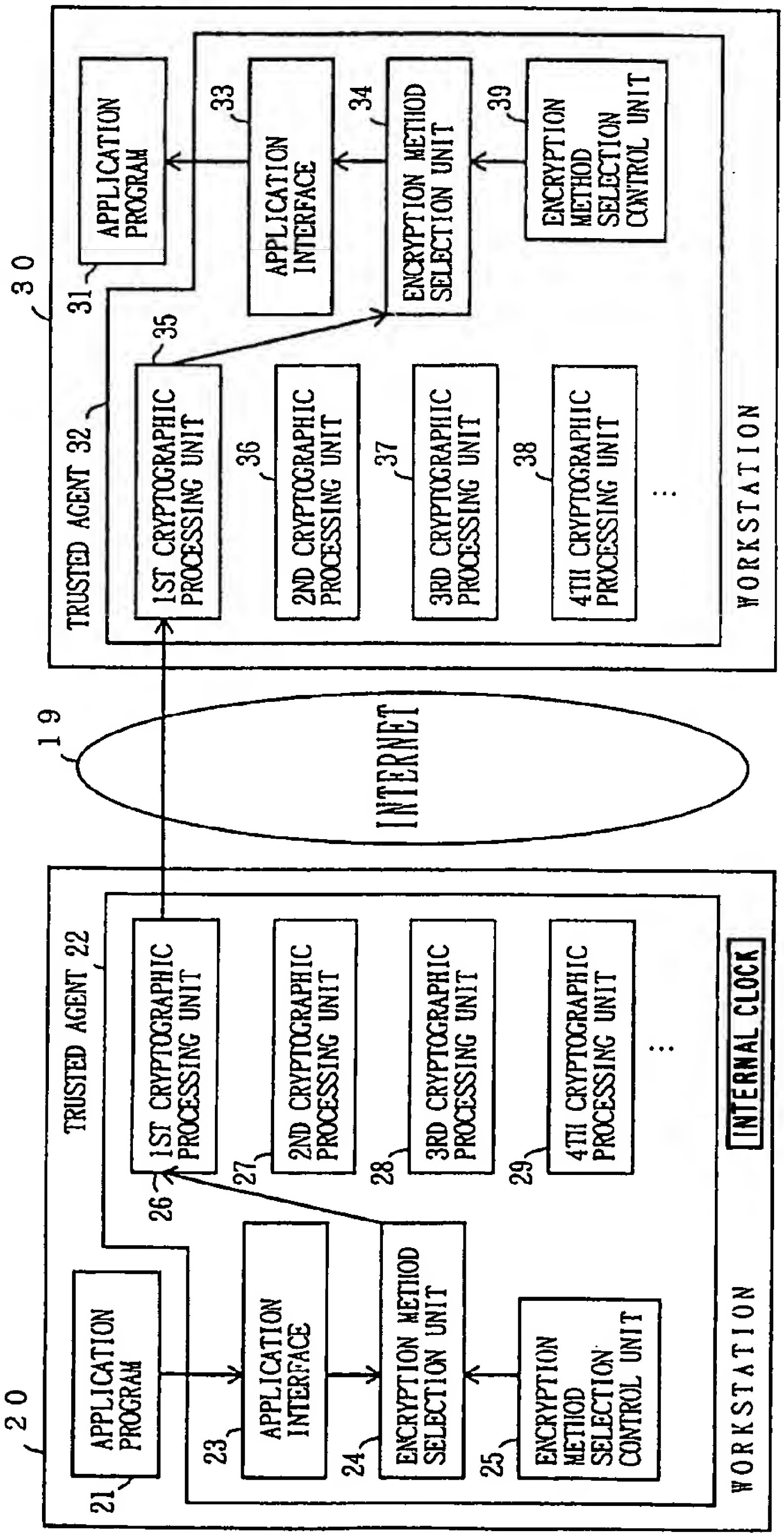

30
TRUSTED AGENT 32
31
APPLICATION PROGRAM
33
APPLICATION INTERFACE
34
ENCRYPTION METHOD SELECTION UNIT
39
ENCRYPTION METHOD SELECTION CONTROL UNIT
35
1ST CRYPTOGRAPHIC PROCESSING UNIT
36
2ND CRYPTOGRAPHIC PROCESSING UNIT
37
3RD CRYPTOGRAPHIC PROCESSING UNIT
38
4TH CRYPTOGRAPHIC PROCESSING UNIT
...
WORKSTATION
19
INTERNET
20
TRUSTED AGENT 22
21
APPLICATION PROGRAM
23
APPLICATION INTERFACE
24
ENCRYPTION METHOD SELECTION UNIT
25
ENCRYPTION METHOD SELECTION CONTROL UNIT
26
1ST CRYPTOGRAPHIC PROCESSING UNIT
27
2ND CRYPTOGRAPHIC PROCESSING UNIT
28
3RD CRYPTOGRAPHIC PROCESSING UNIT
29
4TH CRYPTOGRAPHIC PROCESSING UNIT
...
INTERNAL CLOCK
WORKSTATION

FIG. 6

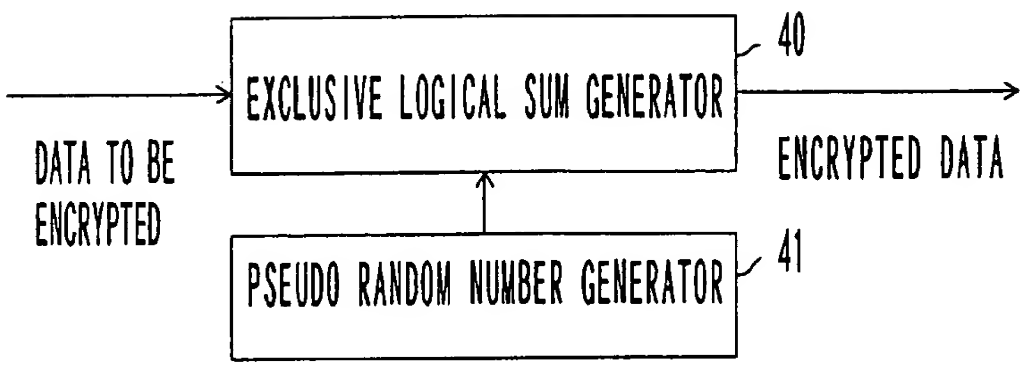

EXCLUSIVE LOGICAL SUM GENERATOR
40
DATA TO BE ENCRYPTED
ENCRYPTED DATA
PSEUDO RANDOM NUMBER GENERATOR
41

FIG. 7A

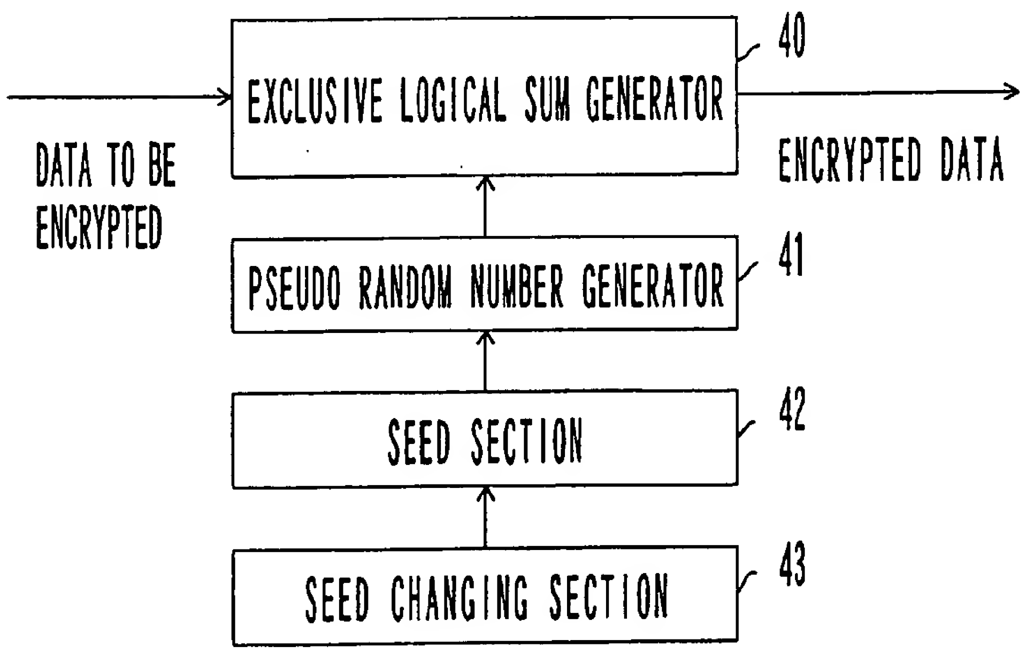

EXCLUSIVE LOGICAL SUM GENERATOR
40
DATA TO BE ENCRYPTED
ENCRYPTED DATA
PSEUDO RANDOM NUMBER GENERATOR
41
SEED SECTION
42
SEED CHANGING SECTION
43

FIG. 7B

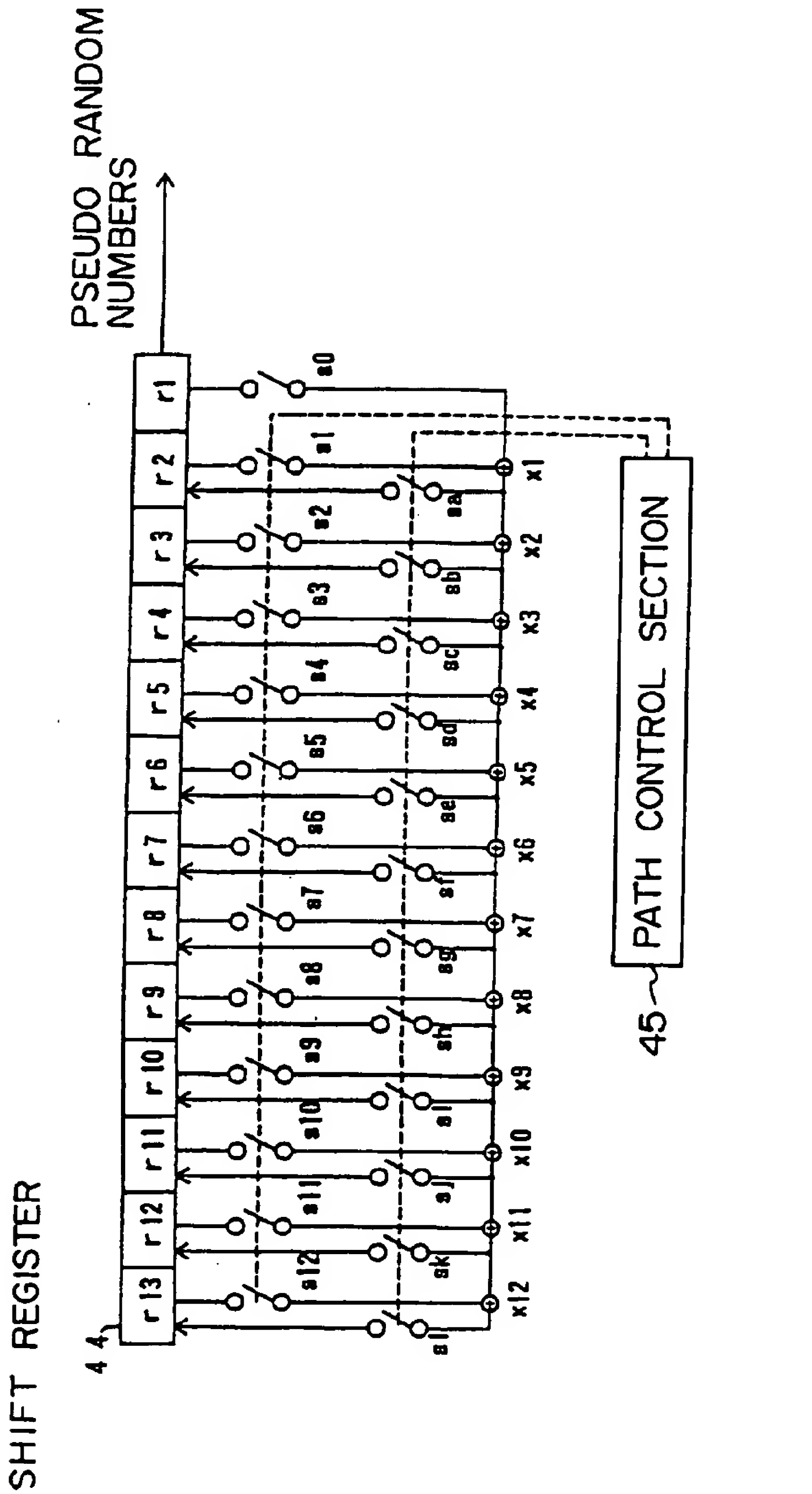

PSEUDO RANDOM NUMBERS
SHIFT REGISTER
44
PATH CONTROL SECTION
45

FIG. 8

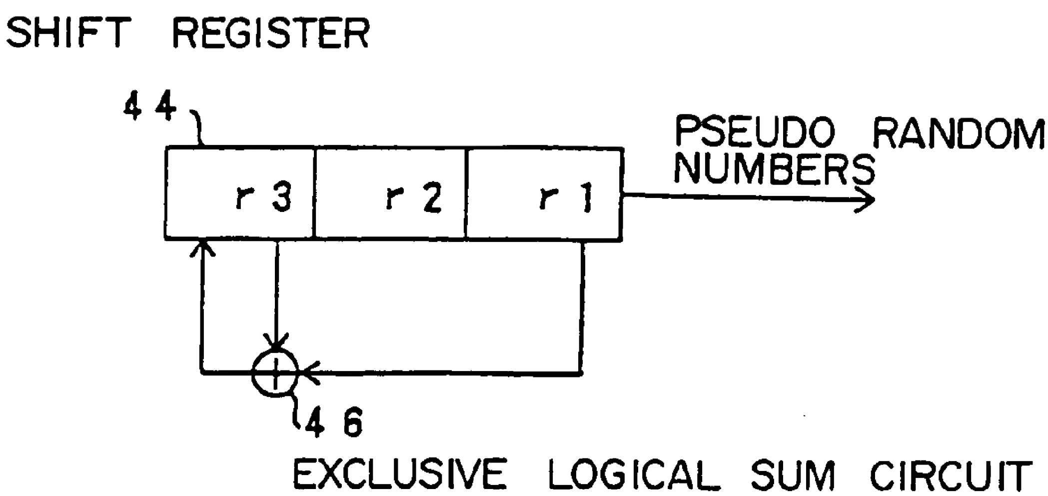
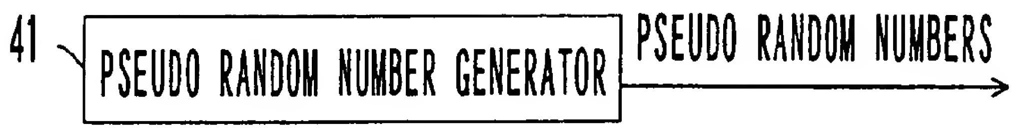
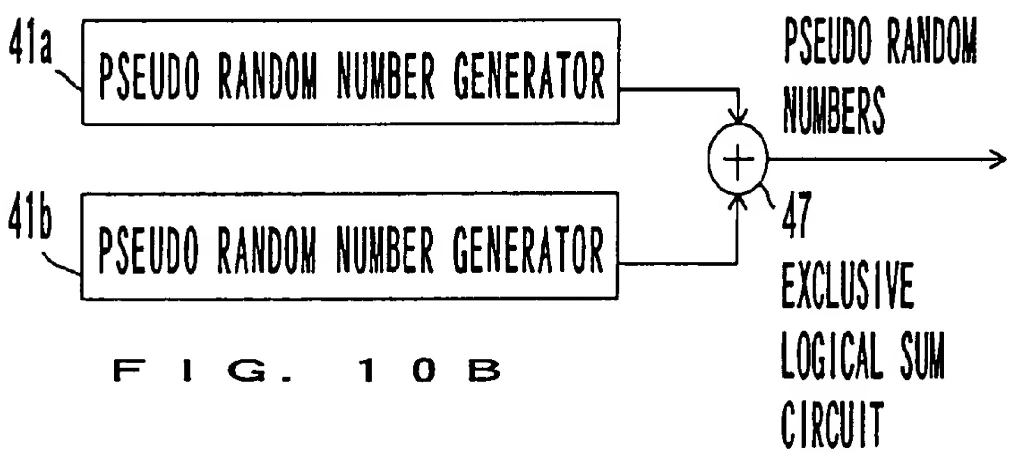

SHIFT REGISTER
44
r3
r2
r1
PSEUDO RANDOM NUMBERS
46
EXCLUSIVE LOGICAL SUM CIRCUIT

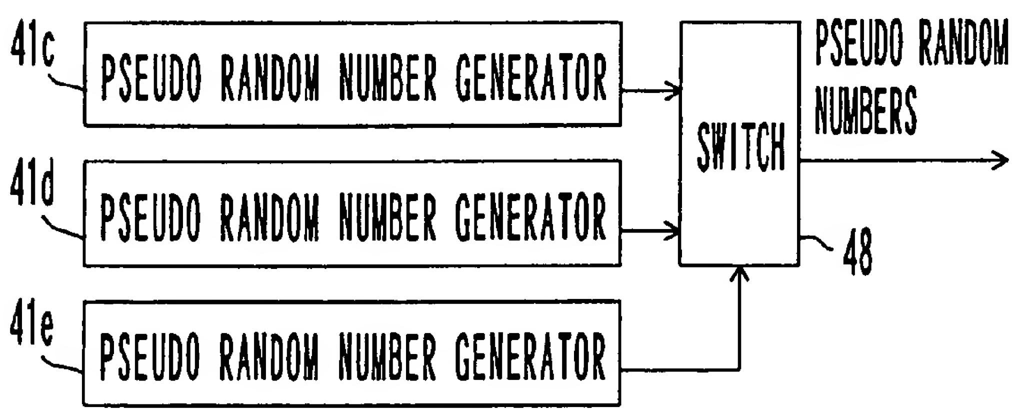
FIG. 9



F I G. 10A



F I G. 10B



F I G. 10C

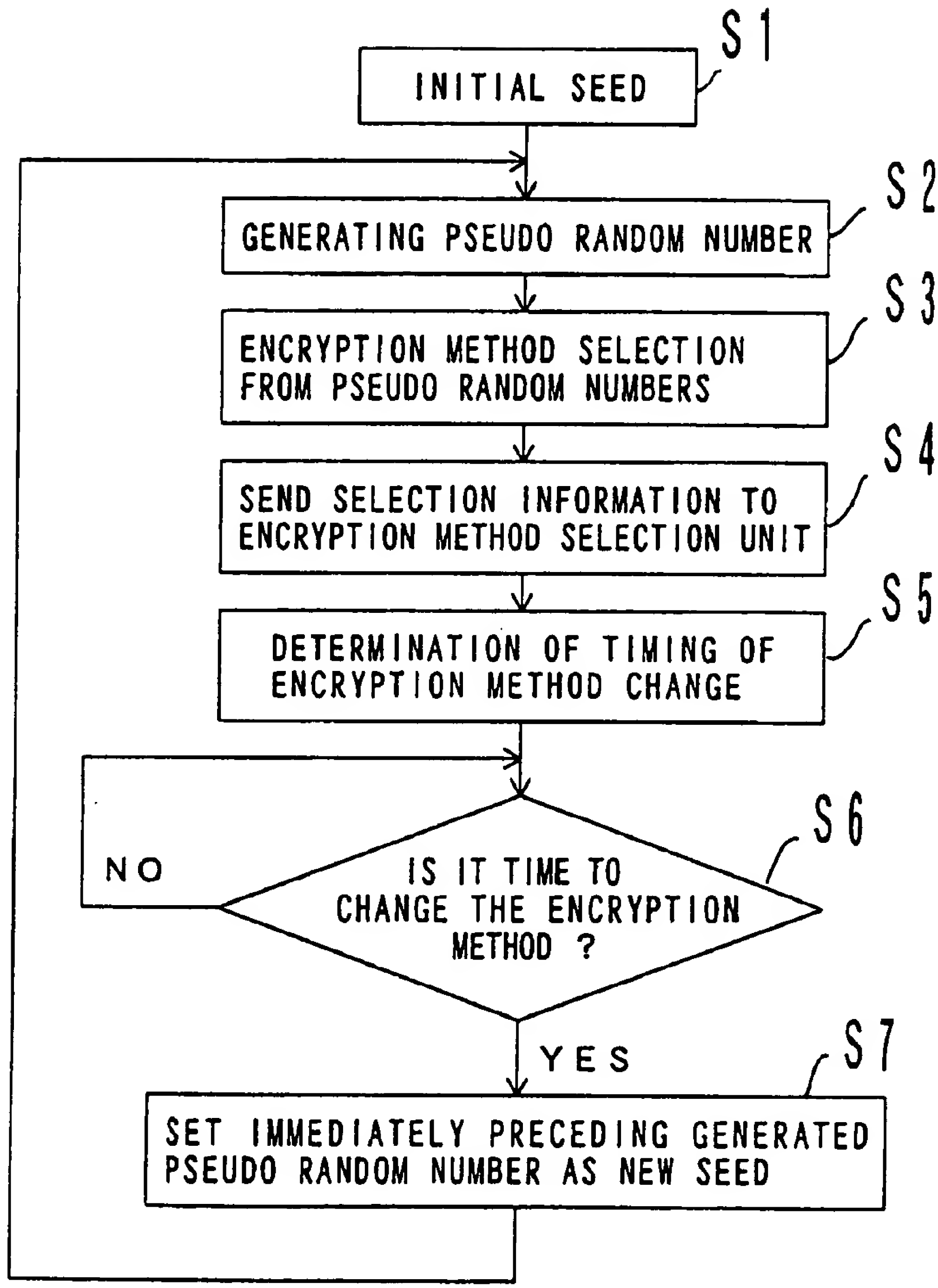

INITIAL SEED
S1
GENERATING PSEUDO RANDOM NUMBER
S2
ENCRYPTION METHOD SELECTION FROM PSEUDO RANDOM NUMBERS
S3
SEND SELECTION INFORMATION TO ENCRYPTION METHOD SELECTION UNIT
S4
DETERMINATION OF TIMING OF ENCRYPTION METHOD CHANGE
S5
IS IT TIME TO CHANGE THE ENCRYPTION METHOD ?
S6
NO
YES
SET IMMEDIATELY PRECEDING GENERATED PSEUDO RANDOM NUMBER AS NEW SEED
S7

FIG. 11

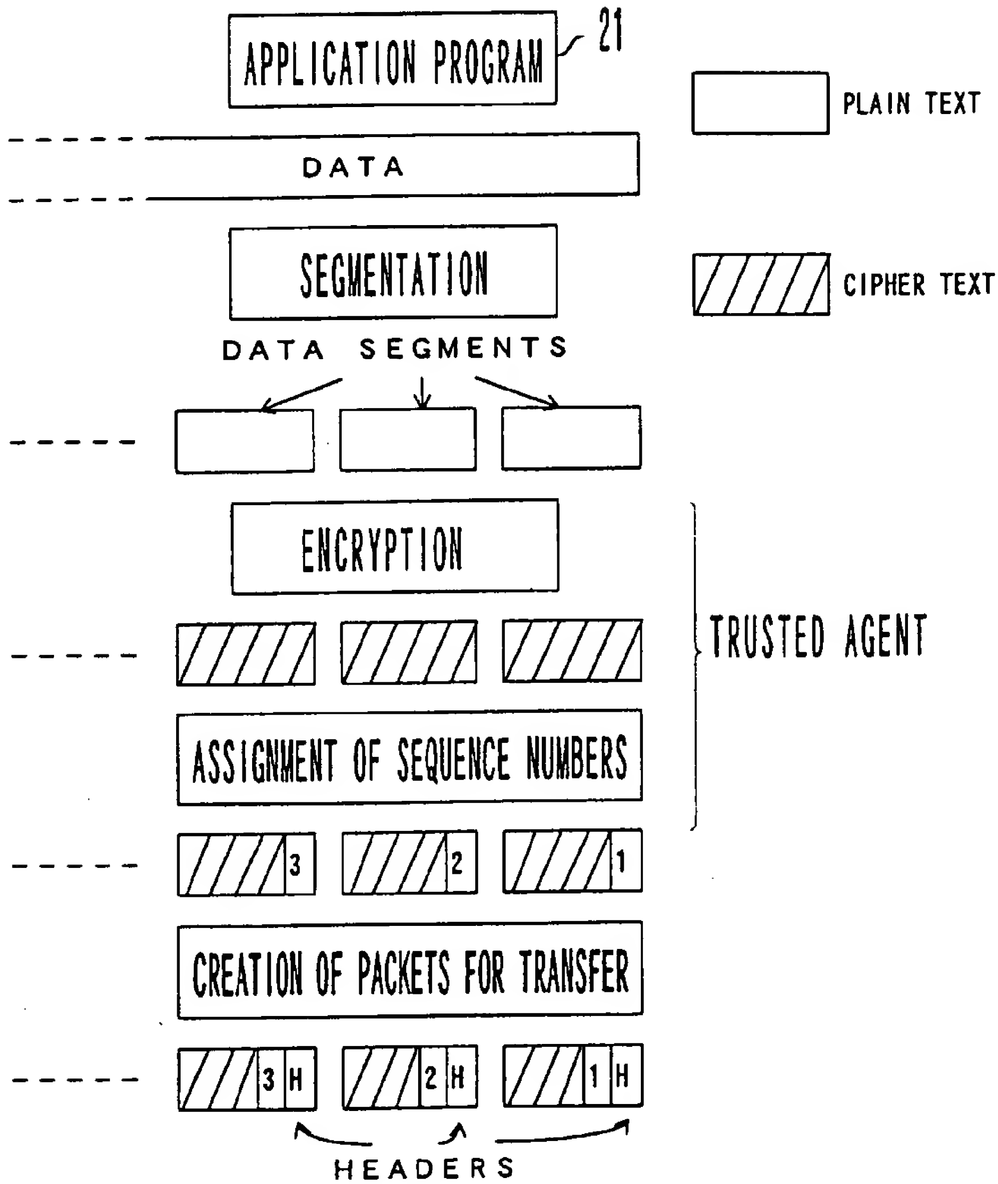


FIG. 12A

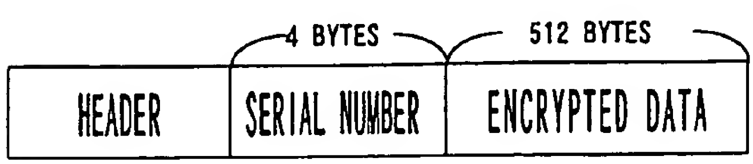


FIG. 12B

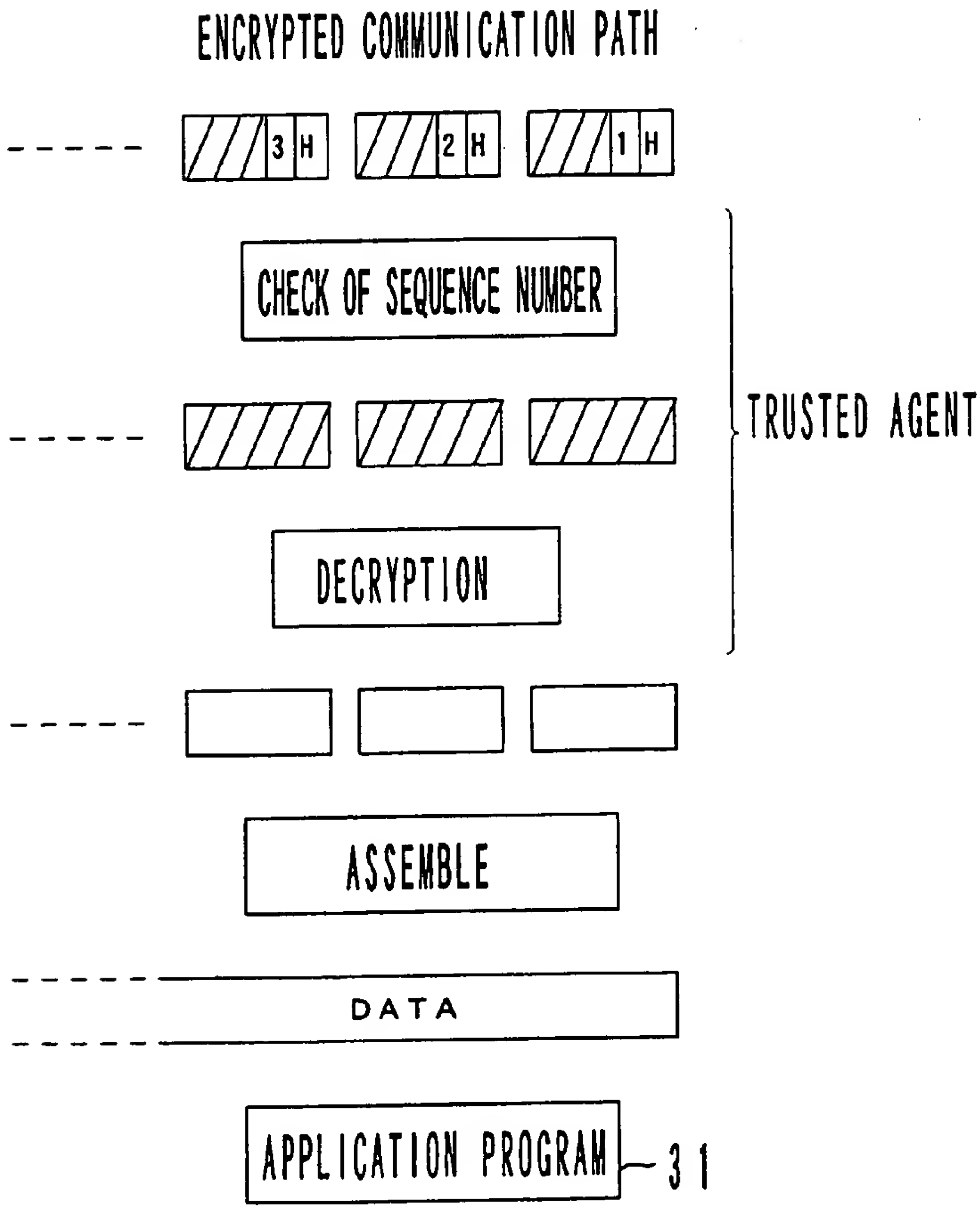

ENCRYPTED COMMUNICATION PATH
3 H
2 H
1 H
CHECK OF SEQUENCE NUMBER
TRUSTED AGENT
DECRYPTION
ASSEMBLE
DATA
APPLICATION PROGRAM
31

FIG. 13

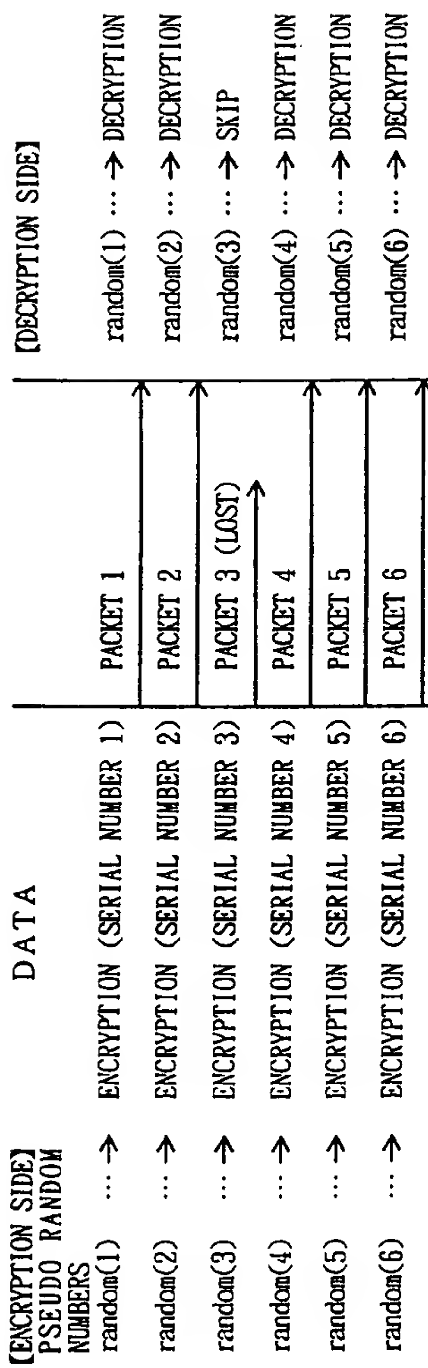


FIG. 14A

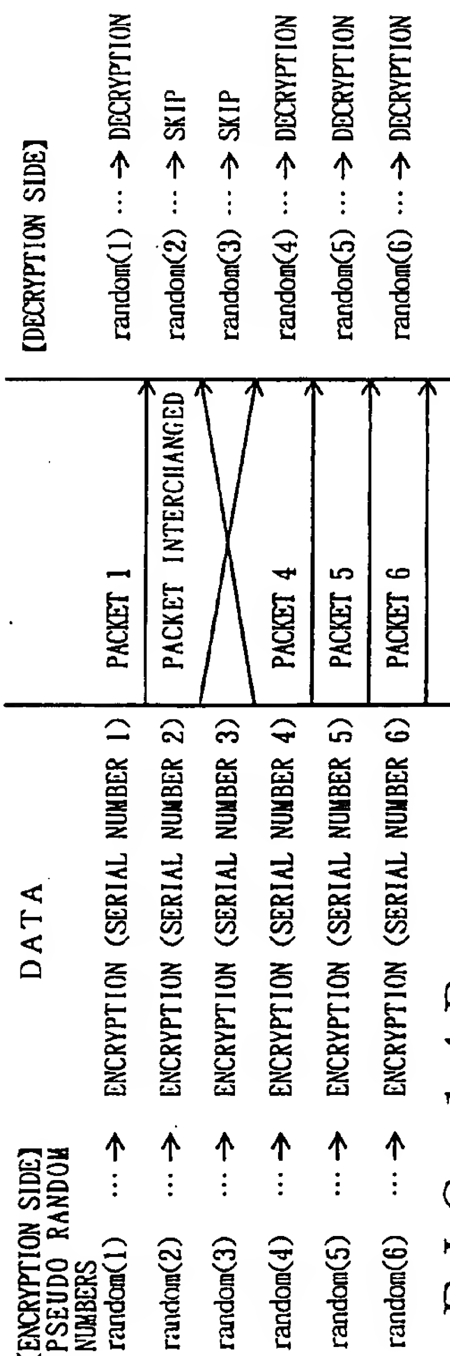


FIG. 14B

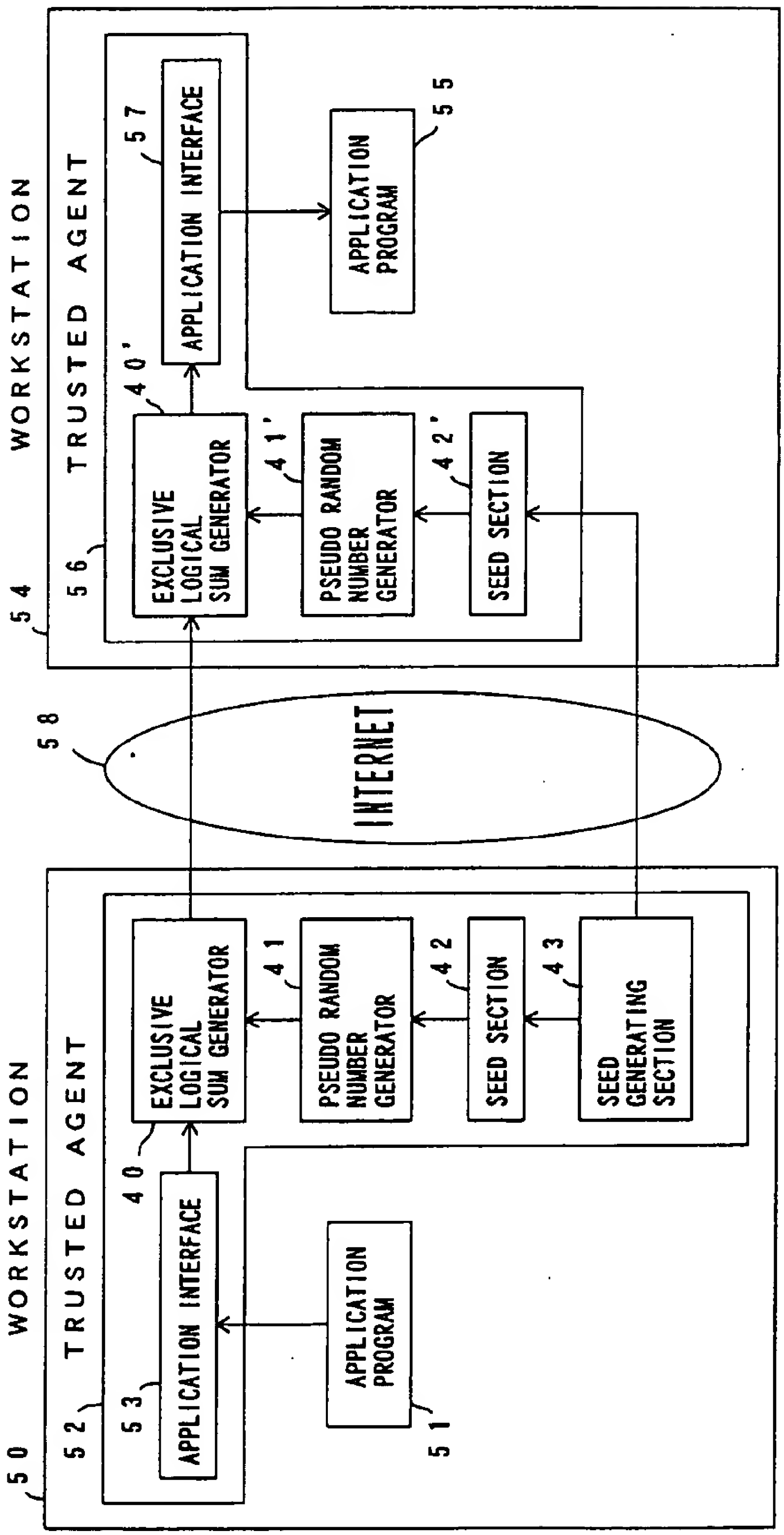

WORKSTATION
TRUSTED AGENT
APPLICATION INTERFACE
EXCLUSIVE LOGICAL SUM GENERATOR
PSEUDO RANDOM NUMBER GENERATOR
SEED SECTION
SEED GENERATING SECTION
APPLICATION PROGRAM
INTERNET
WORKSTATION
TRUSTED AGENT
EXCLUSIVE LOGICAL SUM GENERATOR
PSEUDO RANDOM NUMBER GENERATOR
SEED SECTION
APPLICATION INTERFACE
APPLICATION PROGRAM
50
51
52
53
40
41
42
43
58
54
56
40'
41'
42'
57
55

FIG. 15

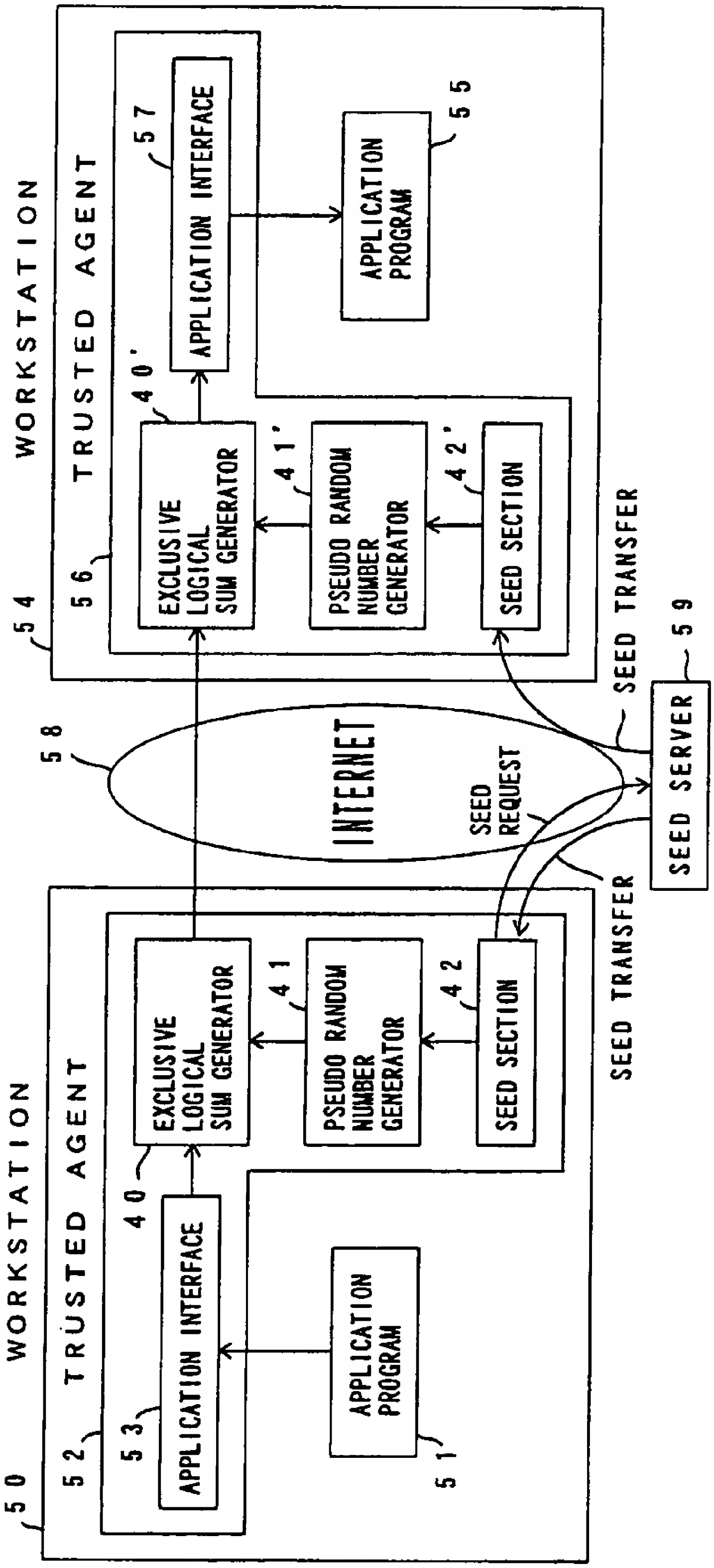

WORKSTATION
TRUSTED AGENT
50
52
53
APPLICATION INTERFACE
APPLICATION PROGRAM
51
40
EXCLUSIVE LOGICAL SUM GENERATOR
41
PSEUDO RANDOM NUMBER GENERATOR
42
SEED SECTION
SEED TRANSFER
SEED REQUEST
58
INTERNET
SEED SERVER
59
SEED TRANSFER
54
56
WORKSTATION
TRUSTED AGENT
40'
EXCLUSIVE LOGICAL SUM GENERATOR
41'
PSEUDO RANDOM NUMBER GENERATOR
42'
SEED SECTION
57
APPLICATION INTERFACE
APPLICATION PROGRAM
55

FIG. 16

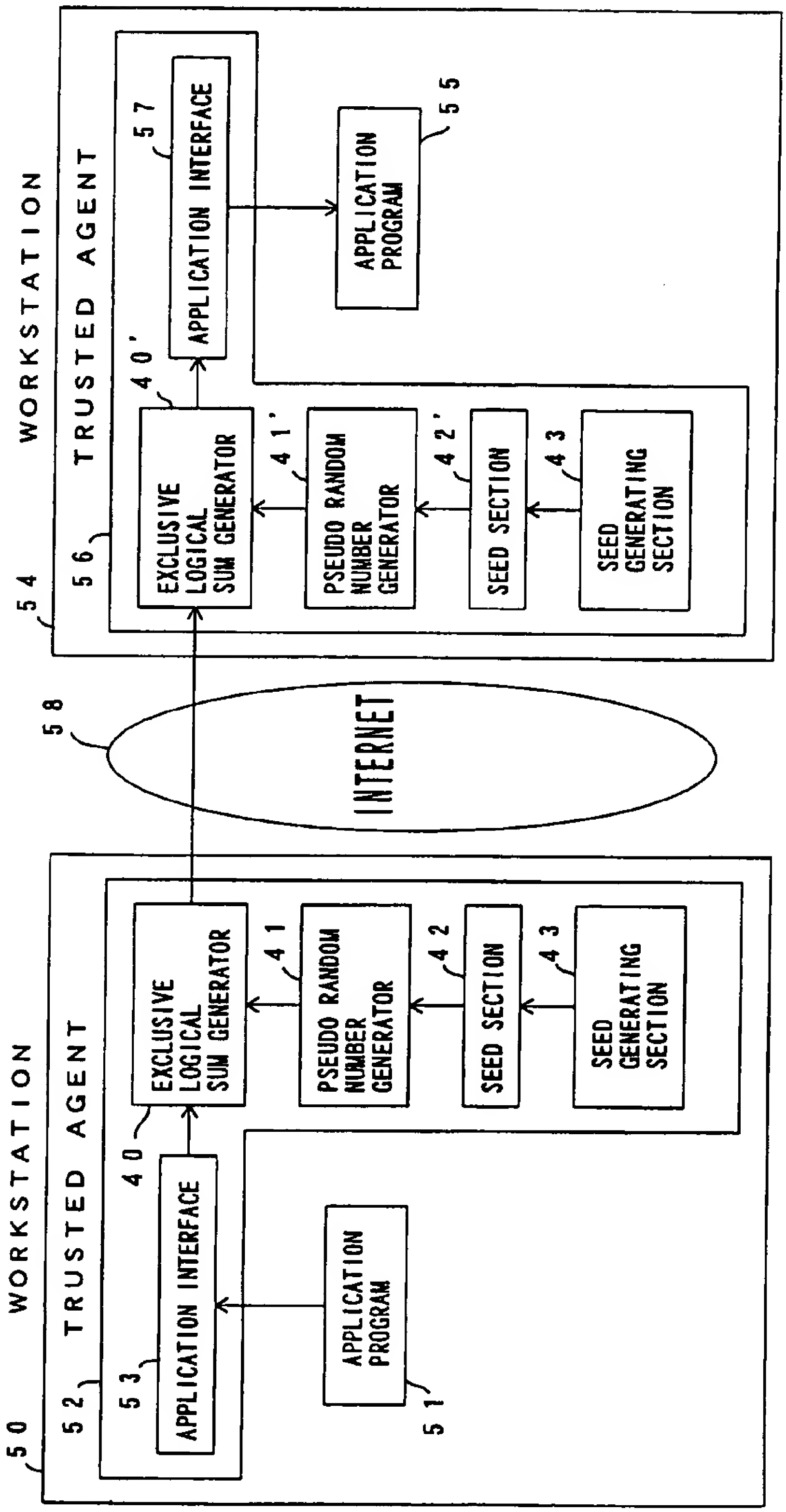

WORKSTATION
TRUSTED AGENT
APPLICATION INTERFACE
APPLICATION PROGRAM
EXCLUSIVE LOGICAL SUM GENERATOR
PSEUDO RANDOM NUMBER GENERATOR
SEED SECTION
SEED GENERATING SECTION
INTERNET
WORKSTATION
TRUSTED AGENT
EXCLUSIVE LOGICAL SUM GENERATOR
PSEUDO RANDOM NUMBER GENERATOR
SEED SECTION
SEED GENERATING SECTION
APPLICATION INTERFACE
APPLICATION PROGRAM
50
51
52
53
40
41
42
43
54
55
56
57
40'
41'
42'
43
58

FIG. 17

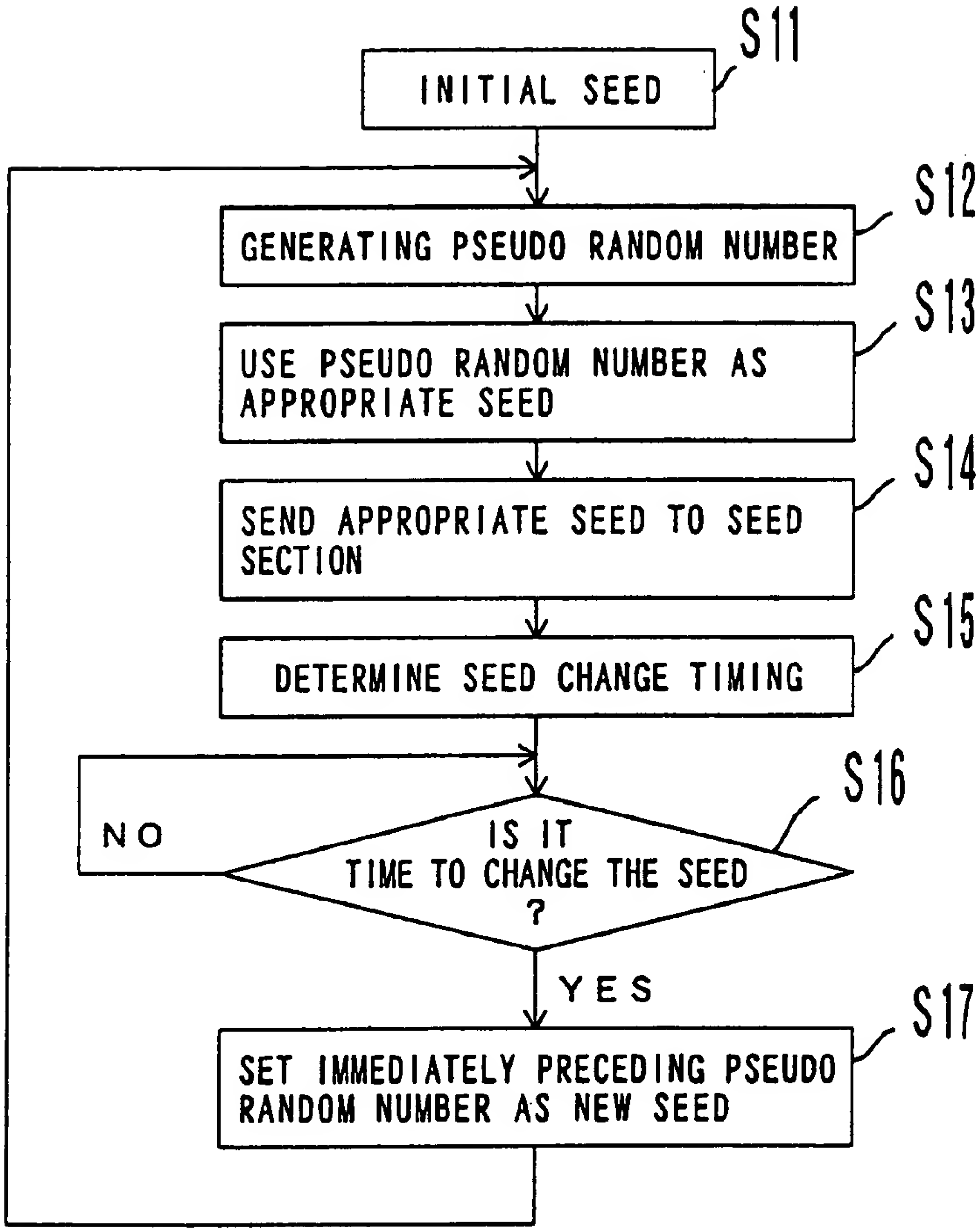

S11
INITIAL SEED
S12
GENERATING PSEUDO RANDOM NUMBER
S13
USE PSEUDO RANDOM NUMBER AS APPROPRIATE SEED
S14
SEND APPROPRIATE SEED TO SEED SECTION
S15
DETERMINE SEED CHANGE TIMING
S16
IS IT TIME TO CHANGE THE SEED ?
NO
YES
S17
SET IMMEDIATELY PRECEDING PSEUDO RANDOM NUMBER AS NEW SEED

FIG. 18

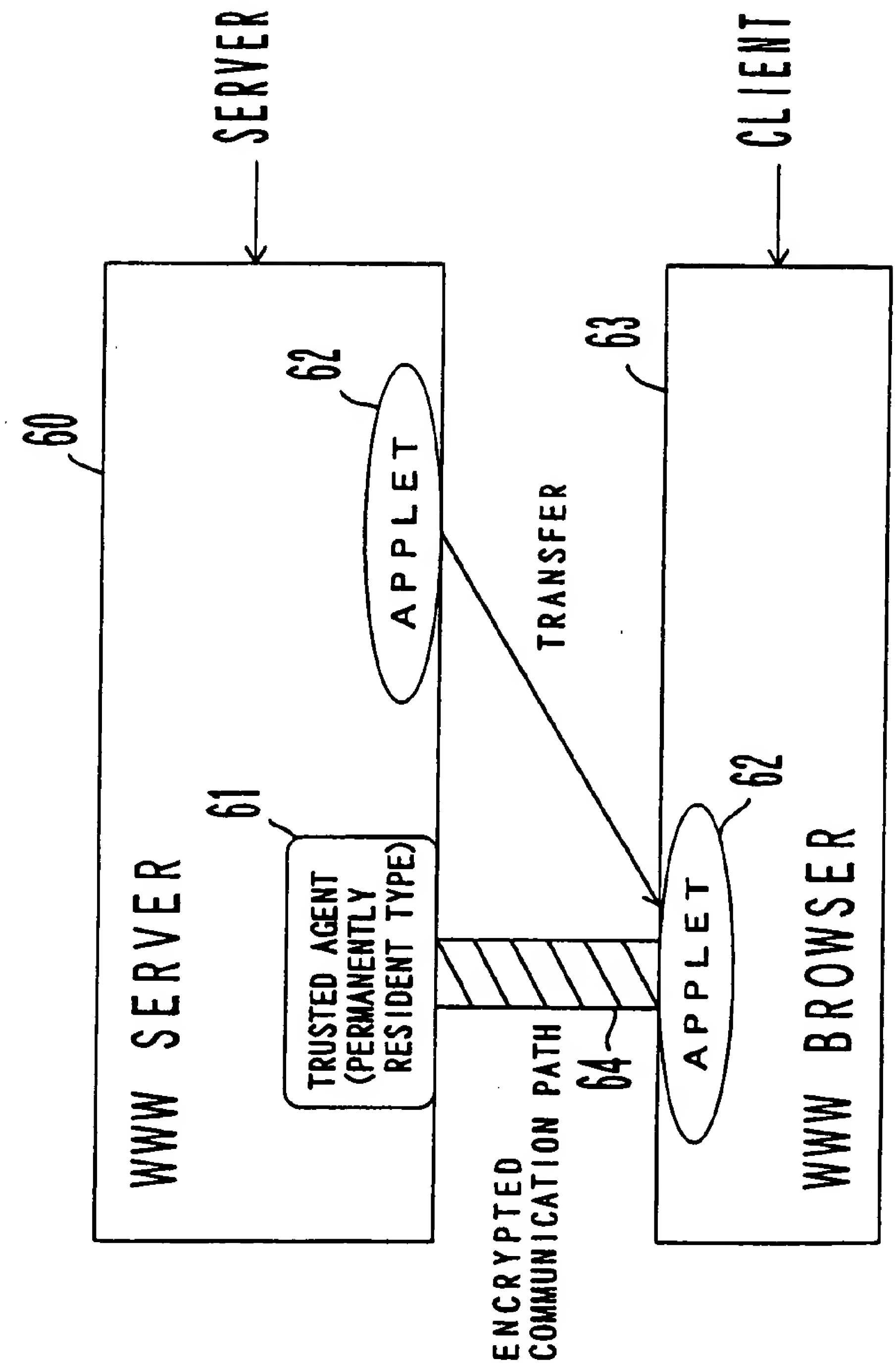
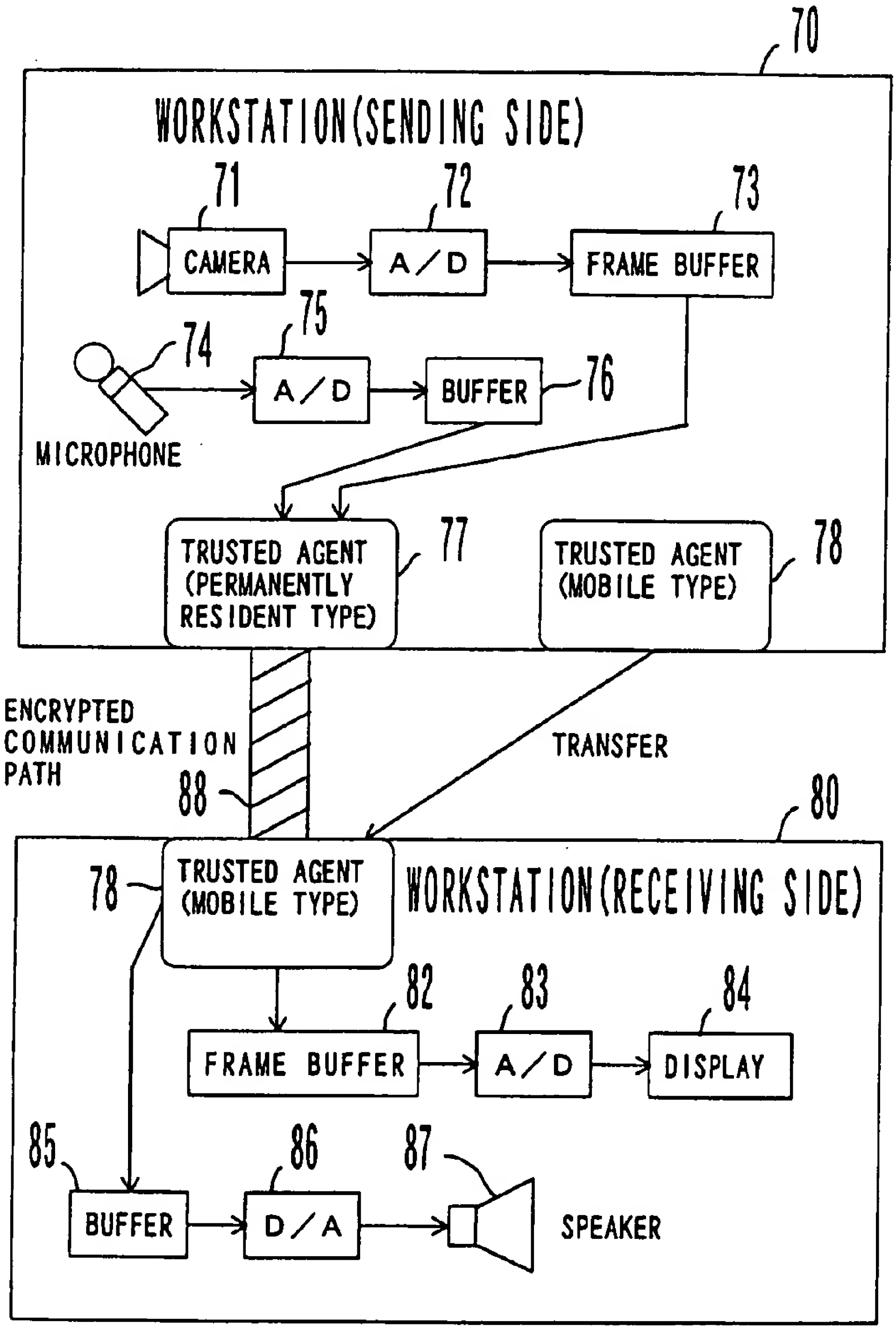

SERVER
CLIENT
60
WWW SERVER
62
APPLET
61
TRUSTED AGENT (PERMANENTLY RESIDENT TYPE)
TRANSFER
63
62
APPLET
WWW BROWSER
64
ENCRYPTED COMMUNICATION PATH

FIG. 19


70
WORKSTATION(SENDING SIDE)
71
72
73
CAMERA
A/D
FRAME BUFFER
74
75
A/D
BUFFER
76
MICROPHONE
TRUSTED AGENT (PERMANENTLY RESIDENT TYPE)
77
TRUSTED AGENT (MOBILE TYPE)
78
ENCRYPTED COMMUNICATION PATH
88
TRANSFER
80
78
TRUSTED AGENT (MOBILE TYPE)
WORKSTATION(RECEIVING SIDE)
82
83
84
FRAME BUFFER
A/D
DISPLAY
85
86
87
BUFFER
D/A
SPEAKER

F I G. 2 0

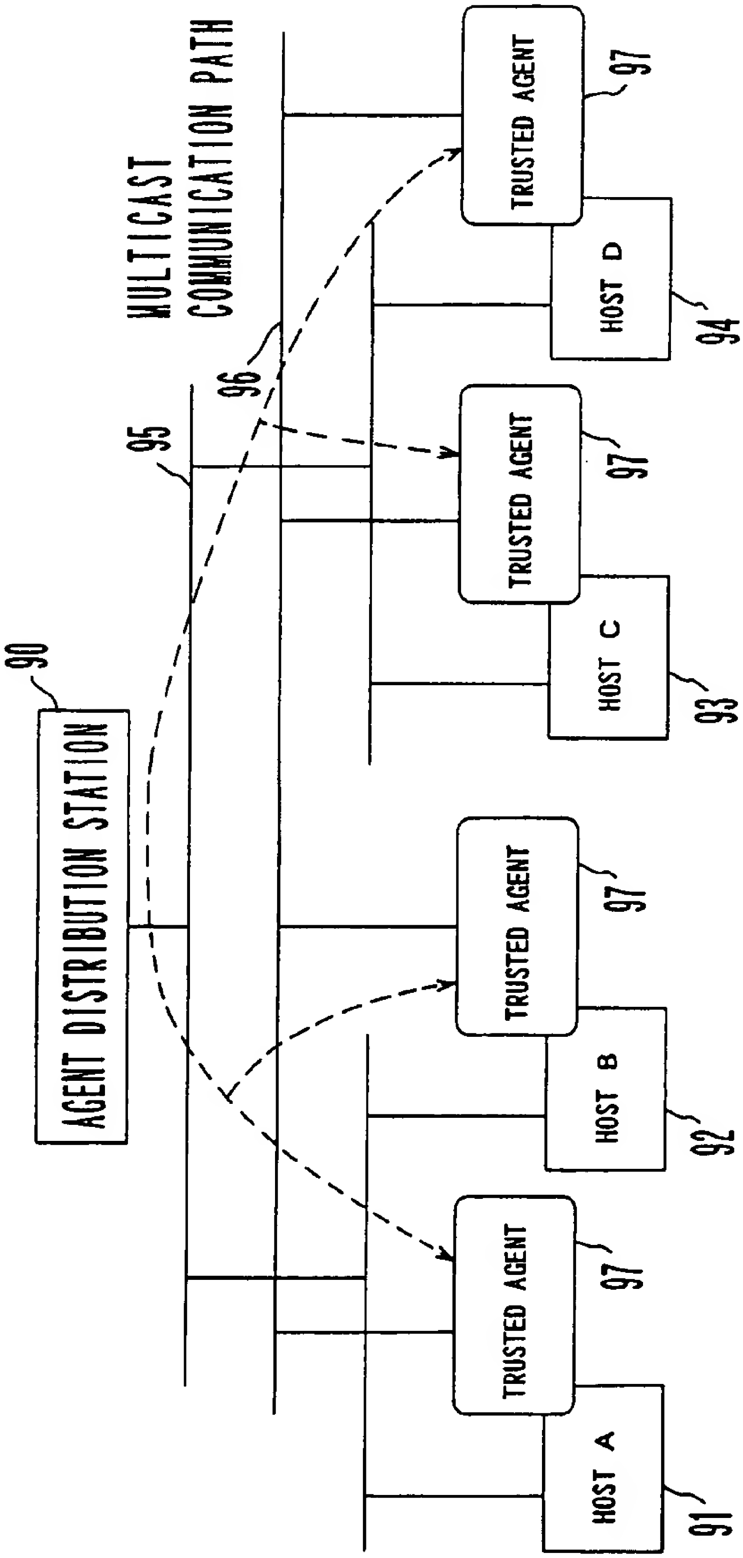

AGENT DISTRIBUTION STATION
90
MULTICAST COMMUNICATION PATH
95
96
TRUSTED AGENT
97
TRUSTED AGENT
97
TRUSTED AGENT
97
TRUSTED AGENT
97
HOST A
91
HOST B
92
HOST C
93
HOST D
94

FIG. 21

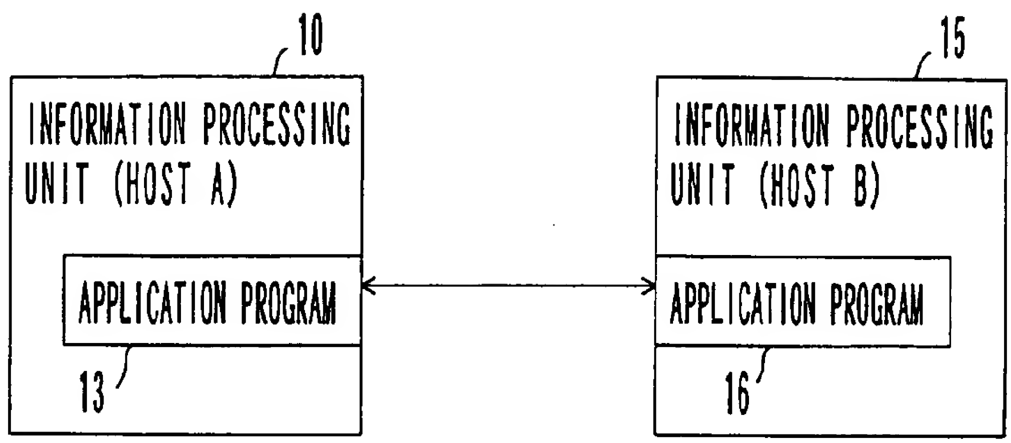


FIG. 22A

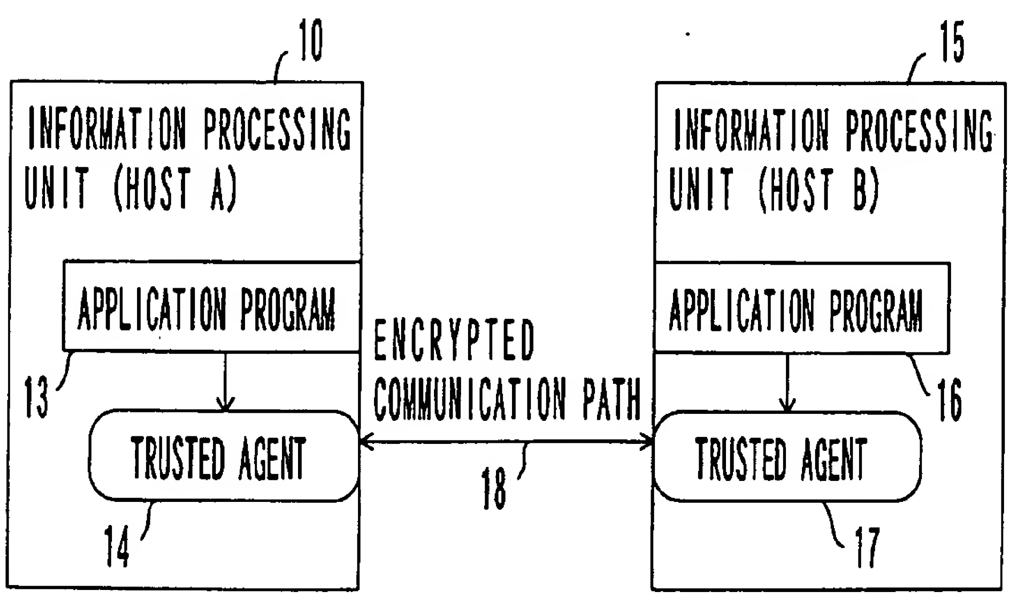


FIG. 22B

(A)

```
import java.applet.Applet;
import java.awt.*;
import java.awt.image.*;
import java.io.*;
import java.net.*;
import java.util.*;
```

(B)

```
public class BM11C extends Applet implements Runnable{

  Image image;
  String hostname , fixfile , imagefile ;
  int port , width , height;
  DataInputStream sodatain;
  PrintStream soprint;
  Thread thread;
  Socket sock;
  Random rann;
```

FIG. 23

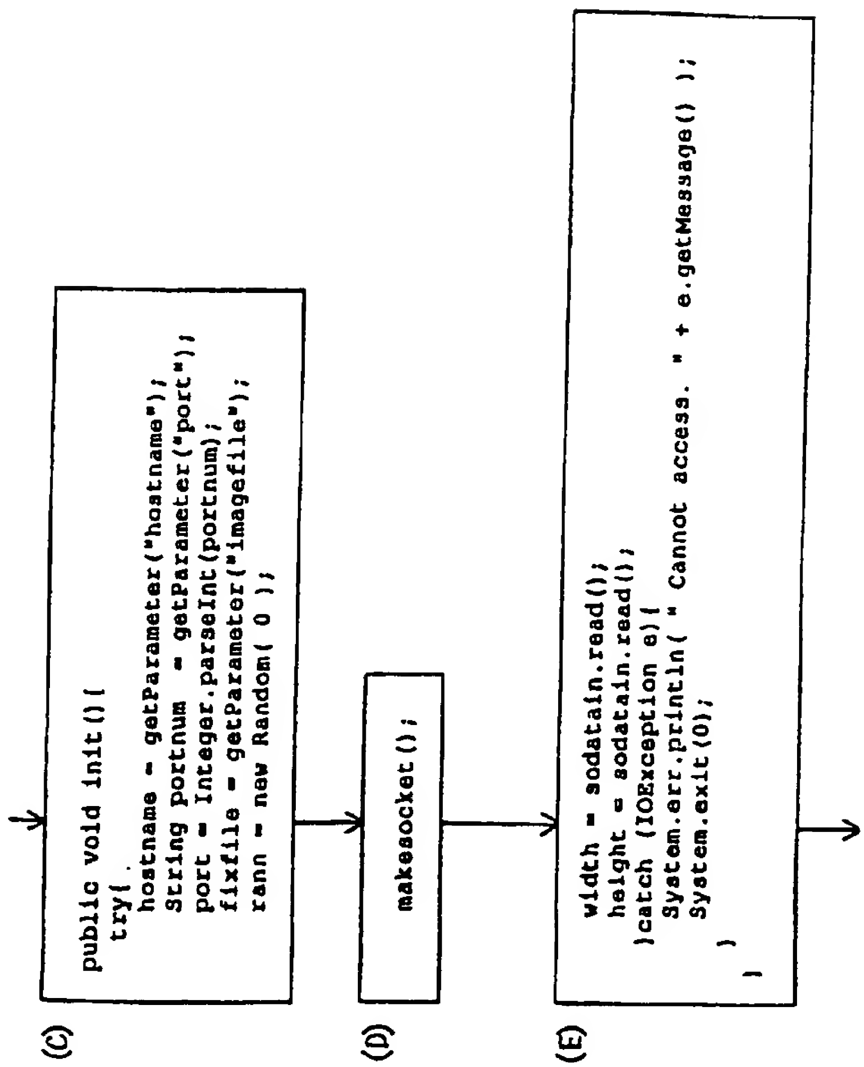

(C)
public void init(){
try{
hostname = getParameter("hostname");
String portnum = getParameter("port");
port = Integer.parseInt(portnum);
fixfile = getParameter("imagefile");
rann = new Random(0);
(D)
makesocket();
(E)
width = sodatain.read();
height = sodatain.read();
}catch (IOException e){
System.err.println(" Cannot access. " + e.getMessage());
System.exit(0);
}
}

FIG. 24

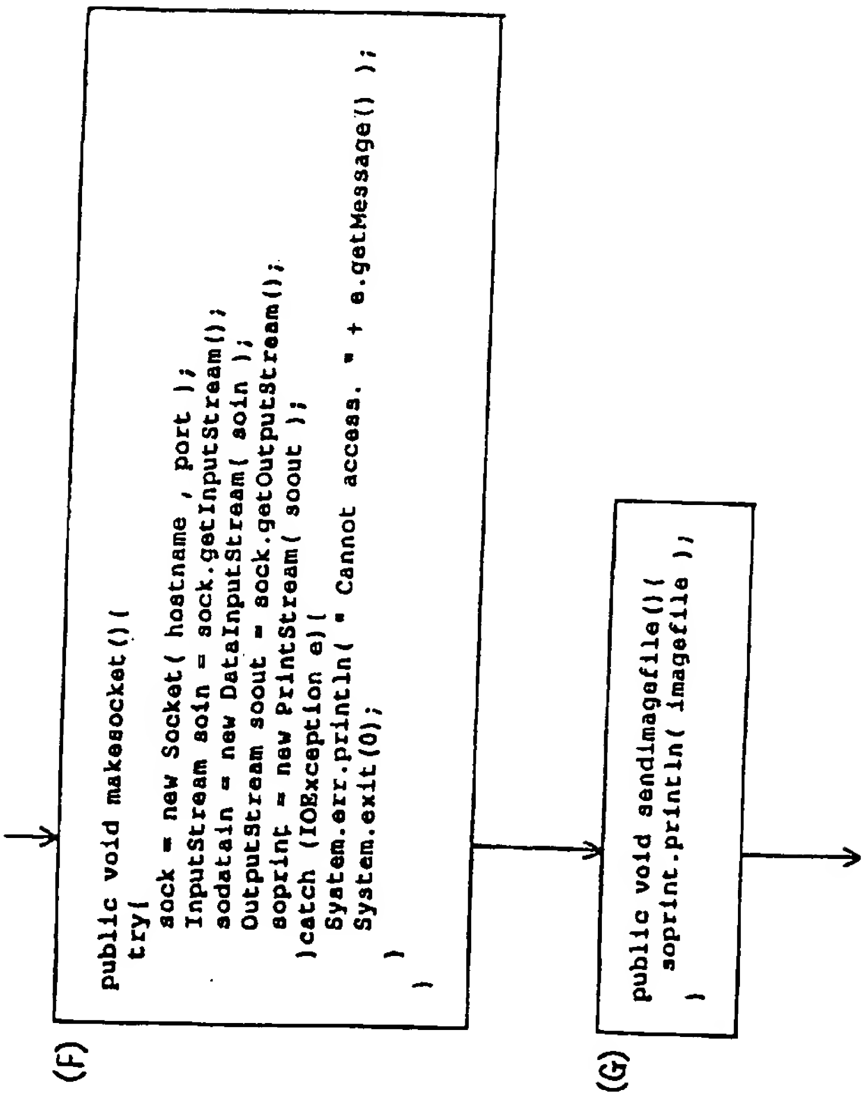

(F)
public void makesocket(){
try{
sock = new Socket(hostname , port);
InputStream soin = sock.getInputStream();
sodatain = new DataInputStream(soin);
OutputStream soout = sock.getOutputStream();
soprint = new PrintStream(soout);
}catch (IOException e){
System.err.println(" Cannot access. " + e.getMessage());
System.exit(0);
}
}
(G)
public void sendimagefile(){
soprint.println(imagefile);
}

FIG. 25

(H)

```
public void getimage(){
  try{
    int index = 0;
    int readnum;
    int maxread=2048;
    int zannsuu;
    int total = width*height*4;
    byte b[] = new byte[2048];
    int pix[] = new int[ width*height ];
    zannsuu = total ;
    while( zannsuu > 0 ) {
      if(zannsuu >= 2048){
        maxread = 2048;
      }else {
        maxread = zannsuu;
      }
```

(I)

```
      if ( ( readnum = sodatain.read( b,0,maxread ) ) == -1 ){
        break ;
      }
```

(J)

```
      rannsuu( b , readnum );
```

FIG. 26

(K)

```
      for(int k=0 ; k<(readnum/4) ; k++){
        pix[index]  =  uint( b[4*k] )    << 24;
        pix[index] |=  uint( b[4*k+1] ) << 16;
        pix[index] |=  uint( b[4*k+2] ) <<  8;
        pix[index] |=  uint( b[4*k+3] ) ;
        index++;
      }
      zannsuu -= readnum;
    }
```

(L)

```
    image = createImage( new MemoryImageSource(width, height, pix, 0, width) )
;
  }catch (IOException e){
    System.err.println( " Cannot access. " + e.getMessage() );
    System.exit(0);
  }
}


int uint( byte a ) {
  if ( a > 0 )
    return (int)a ;
  else
    return (int)( 256 + a ) ;
}
```

FIG. 27

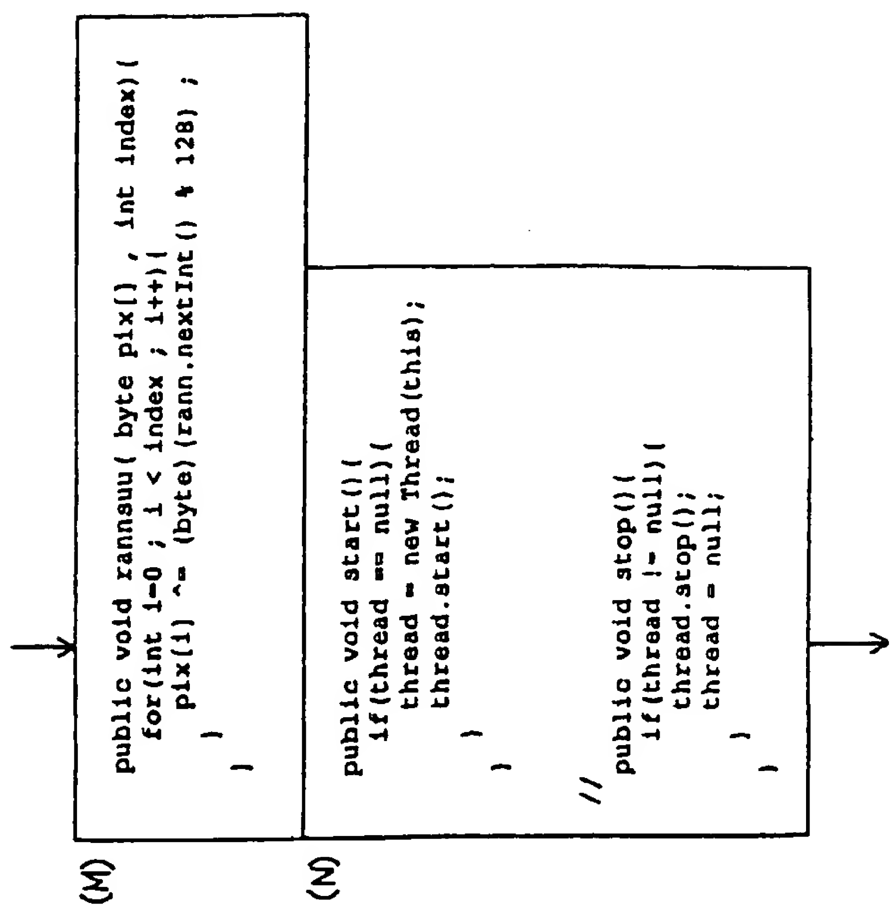

(M)
public void rannsuu(byte pix[] , int index){
for(int i=0 ; i < index ; i++){
pix[i] ^= (byte)(rann.nextInt() % 128) ;
}
}
(N)
public void start(){
if(thread == null){
thread = new Thread(this);
thread.start();
}
}
//
public void stop(){
if(thread != null){
thread.stop();
thread = null;
}
}

FIG. 28

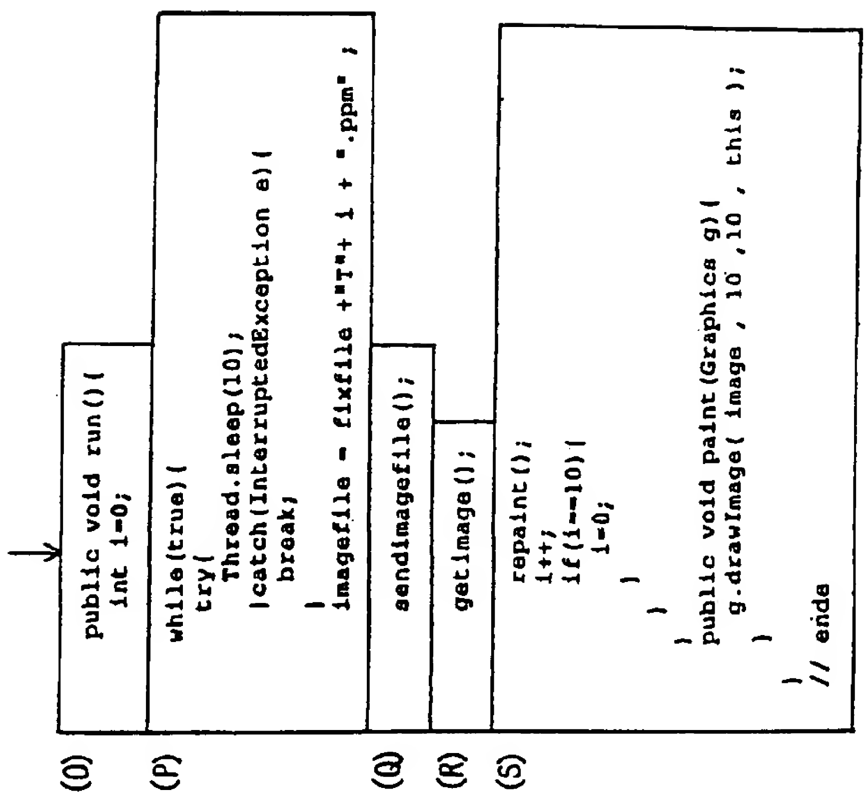

(O)
public void run(){
int i=0;
(P)
while(true){
try{
Thread.sleep(10);
}catch(InterruptedException e){
break;
}
imagefile = fixfile +"T"+ i + ".ppm" ;
(Q)
sendimagefile();
(R)
getimage();
(S)
repaint();
i++;
if(i==10){
i=0;
}
}
}
public void paint(Graphics g){
g.drawImage(image , 10 ,10 , this);
}
}
// ende

FIG. 29

ENCRYPTION COMMUNICATION SYSTEM USING AN AGENT AND A STORAGE MEDIUM FOR STORING THAT AGENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is related to an encryption communication method to prevent the theft and interception of, and tampering with, information in communication between computers; in particular, it relates to a method of encryption using an agent.

2. Description of the Related Art

In recent years, with the explosive spread of the Internet and intranets, the importance of information security has been steadily increasing. Known methods of security in information communication include the method of encryption of information using encryption keys that are possessed in common by terminals, such as the DES (Data Encryption Standard), and a method of encryption such as RSA in which terminals exchange public keys and information is encrypted using their private keys. In addition, to increase the safety of encryption, there are known methods such as changing the encryption key and encryption method over time, as described, for example, in Tokkaihei (Japanese Patent Disclosure) 1-212041.

In a conventional ordinary encryption communication system, the encryption method is public information. For this reason, in order to obtain a strong cryptosystem, the key used in encryption must have a large number of bits. However, when the key used in encryption has a large number of bits, the time required for encryption and decryption processing inevitably becomes long. In particular, when encryption is done in real time applications (such as voice and images) the slowness of the processing in conventional methods such as DES and RSA is a problem.

When encryption is done by a method that involves changing the combination of the encryption key and the encryption method over time, it is necessary to preregister the encryption key and preinstall the encryption program in the terminals that will be used for such encryption communication. Consequently, every time new terminal facilities are added in a network it is necessary to register the encryption key and install the encryption program in those terminals.

SUMMARY OF THE INVENTION

A purpose of this invention is to provide a strong encryption method that has adequate processing speed so that in practice there is no problem in real time transfer of data.

Another purpose of this invention is to make it possible to conduct encrypted communication between terminals without having to preinstall the same encryption program in them.

An encryption communication method of the present invention is based on the system in which encrypted data are transmitted between a first terminal and a second terminal. The method includes the following steps.

A step for transmitting, from the first terminal in which a first agent is installed, the first agent including a program for cryptographic processing, a second agent having substantially the same function as the first agent to the second terminal.

A step for performing an encryption communication between the first agent and the second agent.

Another feature of the present invention is based on the system in which encrypted data are transmitted among a plurality of terminals. The method includes the following steps.

A step for distributing agents including a program for cryptographic processing from an agent distributing server to the plurality of terminals; and

A step for performing an encryption communication between the distributed agents.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. 1 is a diagram explaining an outline of this invention.

FIG. 2 is a configuration diagram of the server and the client.

FIGS 3A and 3B are configuration diagrams of a trusted agent described in mobile code.

FIGS. 4A and 4B are sequence diagrams explaining the processing involved in sending a trusted agent and establishing an encrypted communication path.

FIG. 5 is a configuration diagram of the encrypted communication system of one embodiment of this invention.

FIG. 6 is a configuration diagram of the encrypted communication system of another embodiment of this invention.

FIGS. 7A and 7B are diagrams showing one example of the configuration of a cryptographic processing unit.

FIG. 8 is a diagram showing the hardware circuit of an embodiment of a pseudo random number generator.

FIG. 9 is a diagram showing the configuration of a 3-stage pseudo random number generator that generates the M series.

FIGS. 10A to 10C are figures showing an example of a pseudo random number generation method.

FIG. 11 is a flow chart explaining the action of the encryption method selection control unit.

FIG. 12A is a sequence diagram showing the processing on the sending side when data are sent and received between applications.

FIG. 12B is a configuration diagram of a data packet that transmits cipher text.

FIG. 13 is a sequence diagram showing the processing on the receiving side when data are sent and received between applications.

FIGS. 14A and 14B are diagrams explaining a method of establishing cryptographic synchronization.

FIG. 15 is a diagram showing an example of configuration of an encrypted communication system that changes the seed for the purpose of generating pseudo random numbers.

FIG. 16 is a configuration diagram of an encrypted communication system of another embodiment of this invention.

FIG. 17 is a configuration diagram of an encrypted communication system of still another embodiment of this invention.

FIG. 18 is a flow chart explaining the action of the seed generating section.

FIG. 19 is a configuration diagram for the case in which the encrypted communication system of this embodiment is matched to the WWW.

FIG. 20 is a configuration diagram for the case in which the encrypted communication of this invention is applied to an image transmission/voice transmission system.

FIG. 21 is a configuration diagram of the case in which the encrypted communication of this invention is applied to an electronic conference system.

FIGS. 22A and 22B are diagrams explaining the processing for changing the communication object of an application program when a trusted agent is used.

FIGS. 23 through 29 are figures showing an example of an agent program used to transmit encrypted images described in mobile code.

DETAILED DESCRIPTION OF THE INVENTION

In the encrypted communication system of one embodiment of this invention, first, an agent for the purpose of encryption processing is installed in the sending terminal. Before transferring data, the sending terminal sends an agent having the same function as the installed agent to the receiving terminal. The agent that is sent to the receiving terminal is described in mobile code. When data are transferred, the data are encrypted using that agent in the sending terminal, and decrypted in the receiving terminal using the agent that was sent from the sending terminal.

Thus, in this configuration, it is possible to conduct encrypted communication even with a terminal that does not have a program for encryption processing. At this time, the encryption and decryption processing are executed by the agent, so it is not necessary for the user to be concerned with the encryption method used for that encrypted communication. Moreover, the encryption and decryption processing are performed by agents having the same functions in both the sending terminal and the receiving terminal, so that the cipher text can be reliably decrypted in the receiving terminal. The encryption method can, if desired, be confidential. The security of the encryption can be increased by changing the key needed for encryption synchronously in accordance with rules agreed upon in advance between the agents. Therefore, an encryption method with a small overhead can be selected to reduce processing time.

Embodiments of this invention will be described below with reference to the drawings. FIG. 1 is a diagram that explains an outline of this invention. This diagram shows an example in which information is transferred in encrypted form between a server 10 and a client 15. The server 10 and the client 15 are both computers.

The trusted agent 11 has a program for the purpose of encrypting data, and is described in mobile code. The trusted agent sending unit 12 sends the trusted agent 11 to the client 15. The application program 13 performs processing that accompanies sending data to and receiving data from the client 15. Applications which are envisioned in this embodiment include telephone, television conferences, video transmission, etc., all of which require real-time processing, but the possible applications are not limited to these. The trusted agent 14 is an encrypted program that has the same function as the trusted agent 11; it resides permanently in the server 10.

The application program 16 is basically the same as the application 13. The trusted agent 17 is the trusted agent 11 that was transferred from the server 10. The encrypted communication path 18 is a path established between the trusted agent 14 and the trusted agent 17.

FIG. 2 is a configuration diagram of the server 10 and the client 15. The storage device 501 consists of a semiconductor memory, a magnetic recording medium or an optical recording medium and so on, and stores programs, data, etc. The storage device 501 can be permanently installed in the server 10 or the client 15, or it can be removable.

The storage medium driver 502 is a device that reads out data stored in the portable storage medium 503 (including a semiconductor memory, magnetic disc, optical disc, magneto-optical disc, etc.), or writes data into the portable storage medium 503. The communication control unit 504 is a unit that controls the sending of data to and receiving of data from a network.

The CPU 505 loads programs from the storage device 501 or the portable storage medium 503 into the memory 506 and executes them. Note that programs and data stored in the storage medium 501 may have been written in from the portable storage medium 503, or may be received from another machine on a network via a communication line. The configuration may also be such that the CPU 505 can use programs and data stored in another storage device on a network via a communication line.

The trusted agents 11 and 14 are prestored in the storage device 501 in the server 10. The trusted agents 11 and 14 may be installed from the portable storage medium 503 into the storage device 501, or may be installed from another device on a network into the storage device 501. The trusted agent 14 is loaded into the memory 506 when an encrypted communication is started.

In the client 15, the trusted agent 17 is received via the communication control section 504 and loaded into the memory 506.

The action of the cryptosystem shown in FIG. 1 is as follows. First, before the data communication, the trusted agent sending unit 12 is started up and the trusted agent 11 is sent from the server 10 to the client 15. At this time, the trusted agent 11 is encrypted by a method such as RSA or RSA+DES and transferred.

The processing speeds of RSA, DES, etc. are slow, so they are not the best encryption methods to use for encrypting data that require real time processing such as audio data and video data, but when encrypting a trusted agent, the encryption processing and the decryption processing each only have to be done once, and the amount of data is much less than in the cases of audio data and video data, so that even in the cases of RSA and DES the processing speed does not become a problem.

Next, the trusted agent 14 of the server 10 and the trusted agent 17 of the client 15 establish the encrypted communication path 18. The processing by which the trusted agent 11 is transferred from the server 10 to the client 15, and the processing by which the encrypted communication path 18 between the trusted agent 14 and the trusted agent 17 is established, will be explained later.

The trusted agents 14 and 17 are linked to the application programs 13 and 16, respectively; they encrypt data so that the data cannot be stolen or tampered with, then send and receive the data to/from each other. The encryption between the trusted agent 14 and the trusted agent 17 follows the method described in the programs included in the trusted agents 14 and 17. The trusted agents 14 and 17 can synchronously change the key (a confidential key) necessary for encryption in accordance with a predetermined rule. This increases the strength of the encryption.

FIG. 3 is a configuration diagram of the trusted agent 11 described in mobile code. As shown in FIG. 3A, the trusted agent 11 consists of an application interface section 11-1 and a cryptographic processing section 11-2. The application interface section 11-1 has the role of exchanging signals between an ordinary application program (here, application 16) and the cryptographic processing section 11-2; the cryptographic processing section 11-2 encrypts and decrypts signals to/from the application interface section 11-1. Another function that the application interface section 11-1 has is to absorb differences due to different operating systems when the API depends on the operating system.

In FIG. 3B, the trusted agent 11 has an application program section 11-3. In this case, the application program

stored in the trusted agent 11 is described in mobile code, and the application program section 11-3 is transmitted together with the application interface section 11-1 and the cryptographic processing section 11-2.

FIG. 4A is a sequence diagram that explains the processing by which a trusted agent is sent and an encrypted communication path is established. Here it is assumed that the server 10 is the terminal that sends the trusted agent, and the client 15 is the terminal that receives the trusted agent. It is further assumed that the encryption method uses pseudo random numbers. As will be explained in detail later, the pseudo random numbers are generated based on an "initial seed".

When encrypted communication is started, first an initial seed is generated in the server 10. The initial seed is, for example, generated based on the time. Next, that initial seed is set in the trusted agents 11 and 14. Then the trusted agent 11 in which the initial seed has been set is sent to the client 15. As discussed above, the trusted agent 11 is transferred after having been encrypted by the RSA or DES method. Then the server 10 starts the trusted agent 14.

It is assumed that in the client 15, a program to receive the agent has been started up. When the client 15 receives the trusted agent 11, that trusted agent 11 is loaded into memory and started up as the trusted agent 17.

The trusted agents 14 and 17 establish a encrypted communication path; after that, cipher text is sent and received via that encrypted communication path.

FIG. 4B is a diagram that explains the procedure by which an encrypted communication path between trusted agents is established. Here it is assumed that the trusted agent 14 has already been started up. The cryptographic processing sections of the trusted agents 14 and 17 each consist of a sending section and a receiving section. The sending section encrypts data from an application program and performs send processing; the receiving section converts encrypted data to plain text or appropriate application data and performs processing to transfer the data to an application program. The sending section and the receiving section are realized by, for example, threads.

First, the sending section of the trusted agent 14 sends a request for connection to the receiving section of the trusted agent 17. If, for example, the transmission path is an ethernet, this connection request is transferred by a TCP packet. Since, at this time, the connection request will be refused if the trusted agent 17 has not been started up, in this case the sending section of the trusted agent 14 repeatedly issues the connection request until a response is received from the receiving section of the trusted agent 17.

When the receiving section of the trusted agent 17 sends a response message in response to the connection request and the receiving section of the trusted agent 14 receives that message, a path is established between the sending section of the trusted agent 14 and the receiving section of the trusted agent 17. The procedure for establishing a path between the sending section of the trusted agent 17 and the receiving section of the trusted agent 14 is similar.

After that, the sending section of the trusted agent 14 encrypts data from the application program 13 and then sends the encrypted data to the trusted agent 17 via the path that has been established. The receiving section of the trusted agent 17 decrypts the received cipher text or encrypted data and transfers the resulting plain text or appropriate application data to the application program 16. The procedure for sending encrypted data in the opposite direction is similar. The encrypted data are, for example, stored in a UDP packet and then transferred.

FIG. 5 is a configuration diagram of the encrypted communication system of one embodiment of this invention. The workstations 20 and 30 correspond to the server 10 and the client 15, respectively, in FIG. 1. The application programs 21 and 31 correspond to the application programs 13 and 16, respectively, in FIG. 1. The trusted agents 22 and 32 correspond to the trusted agents 14 and 17 in FIG. 1, respectively. The workstation 20 and the workstation 30 are connected to each other via the Internet 19.

The trusted agent 22 has the cryptographic processing units 26 to 29. Each of the cryptographic processing units 26 to 29 encrypts data by a different method from the others. The encryption method selection unit 24 selects one of the cryptographic processing units 26 to 29 in accordance with an instruction from the encryption method selection control unit 25, and transfers data received via the application interface section 23 to the selected cryptographic processing unit. The encryption method selection control unit 25 generates and outputs an instruction signal for the purpose of selecting one from among the cryptographic processing units 26 to 29 in accordance with a specified algorithm. The method by which this instruction signal is generated will be described below. The application interface section 23 is basically the same as the application interface section 11-1 shown in FIG. 3A and FIG. 3B.

The trusted agent 32 has been transferred from the workstation 20. The application interface unit 33, the encryption method selection unit 34 and the cryptographic processing units 35 to 38 are basically the same, respectively, as the application interface unit 23, the encryption method selection unit 24 and the cryptographic processing units 26 to 29 which make up the trusted agent 22. The trusted agent 32 does not have a unit corresponding to the encryption method selection control unit 25; the encryption method selection unit 34 selects one of the cryptographic processing units 35 to 38 in accordance with an instruction signal generated by the encryption method selection control unit 25.

The action of the encrypted communication system shown in FIG. 5 is as follows. First, the trusted agent 32 that is described in mobile code is encrypted and transferred from the workstation 20 to the workstation 30.

Next, the encryption method that is necessary for the encrypted communication is determined in the encryption method selection control unit 25. The encryption method selection control unit 25 transfers information instructing which encryption method is to be used to the encryption method selection unit 24, and to the encryption method selection unit 34 of the workstation 30. This secures the encrypted communication path.

When, for example, the encryption method selection control unit 25 selects the first encryption method, then, as shown in FIG. 5, in the workstation 20 data are encrypted using the 1st cryptographic processing unit 26, and in the workstation 30 the cipher text or encrypted data is decrypted using the 1st cryptographic processing unit 35.

Communication data from the application program 21 are encrypted in the cryptographic processing unit selected by the encryption method selection unit 24 via the application interface unit 23. The example shown in FIG. 5 shows the case in which the 1st cryptographic processing unit 26 has been selected.

The encrypted data are sent to the workstation 30 via the Internet 19. Data (cipher text or encrypted data) received by the workstation 30 are decrypted in the cryptographic processing unit selected by the encryption method selection unit 34 (in this example, the 1st cryptographic processing unit

35), and transferred to the application program 31 in the workstation 30 via the application interface unit 33.

Data transmission from the application program 31 in the workstation 30 to the application program 21 in the workstation 20 is carried out by a similar encryption procedure.

The encryption method selection control unit 25 selects new encryption methods at regular or irregular intervals, and posts the selection results to the encryption method selection unit 24 of the workstation 20 and the encryption method selection unit 34 of the workstation 30. In this kind of configuration, the encryption method changes with time, making it difficult to decipher the encrypted data.

In the embodiment described above, the encryption method selection control unit 25 is provided in the workstation 20, but it is also possible to, for example, install an encryption method instruction server on the network, and to have the trusted agents switch their encryption methods based on instructions from that encryption method instruction server.

Also, in the embodiment described above, the cryptographic processing units are within the trusted agents, but it is also possible to install a cryptographic processing unit distribution server that distributes programs for the purpose of cryptographic processing described in mobile code on a network, and to have programs for the purpose of cryptographic processing distributed from the cryptographic processing unit distribution server to the trusted agents.

FIG. 6 is a configuration diagram of the encrypted communication system of another embodiment of this invention. In FIG. 6, the previous explanations apply without change to components to which the same symbols that were used in FIG. 5.

In the system shown in FIG. 6, the encryption method selection control unit 39 is provided in the trusted agent 32. The encryption method selection control unit 39 is the same as the encryption method selection control unit 25 within the trusted agent 22. Consequently, the trusted agent 32 can select the same encryption method by itself as the encryption method selected by the trusted agent 22 without receiving an instruction for the purpose of encryption method selection from the trusted agent 22.

Now let us explain the action of the encrypted communication system shown in FIG. 6. First, the trusted agent 32 is transferred from the workstation 20 to the workstation 30. This processing is as explained with reference to FIG. 5.

The encryption method selection control unit 25 in the workstation 20 and the encryption method selection control unit 39 in the workstation 30 determine their respective encryption methods independently of one another, and post those respective encryption methods that have been determined to the encryption method selection unit 24 of the workstation 20 and the encryption method selection unit 34 of the workstation 30, respectively. Here, the encryption method selection control units 25 and 39 have synchronization functions in the encryption method selection, so that the same encryption method is selected by the encryption method selection control units 25 and 34.

Let us now simply explain what is meant by "synchronization functions in the encryption method selection". The encryption method selection control units 25 and 39 respectively output results obtained in accordance with given initial conditions. The initial conditions given to the encryption method selection control unit 39 are set in the workstation 20. These initial conditions are the same as those given to the encryption method selection control unit 25. In FIG. 4, which was discussed above, the same initial seeds were set in 2 trusted agents as initial conditions. Here, the encryption method selection control units 25 and 39 have the same functions as one another, so that when the encryption method selection control units 25 and 39 are given the same initial conditions, they will generate the same results. Consequently, the encryption method selection control units 25 and 39 act independently of each other, but output the same values as signals that indicate the encryption method to be used. This is called synchronization in the selection of the encryption method.

By means of the synchronization function, the same encryption method is always selected in the workstation 20 and the workstation 30, without the sending and receiving of information between them. This secures an encrypted communication path.

The action by which data are encrypted and sent and received between the application programs 21 and 31 is as explained in FIG. 5. That is to say, communication data from the application program 21 are encrypted in the cryptographic processing unit selected by the encryption method selection unit 24. The encrypted data are sent to the workstation 30 via the Internet 19. The data (cipher text or cipher data) received by the workstation 30 are decrypted in the cryptographic processing unit selected by the encryption method selection unit 34, and transferred to the application program 31 in the workstation 30.

Thus, the system shown in FIG. 6 is different from the system shown in FIG. 5 in that the encryption method selection control units 25 and 39 are mutually independent and the encryption methods are sequentially selected. The encryption method selection control units 25 and 39 select new encryption methods at regular or irregular intervals,and send those selection results to the encryption method selection unit 24 and the encryption method selection unit 34, respectively. In this configuration, the encryption method is changing with time, making it hard to decipher the encrypted data.

FIG. 7 shows an example of configuration of a cryptographic processing unit. The following discussion assumes that pseudo random numbers are being used in the encryption method.

Theoretically, as shown for example in FIG. 7A, the cryptographic processing unit consists of an exclusive logical sum generator 40 and a pseudo random number generator 41. The pseudo random number generator 41 may be a variable period type. The encrypted data (cipher text) are obtained by inputting the data to be encrypted (plain text) and pseudo random numbers generated by the pseudo random number generator 41 into the exclusive logical sum generator 40. The configuration is basically the same when the cipher text is decrypted into plain text.

FIG. 7B shows another example of a cryptographic processing unit. In this example, the cryptographic processing unit has, in addition to the exclusive logical sum generator 40 and the pseudo random number generator 41, a seed section 42 that generates seeds for the purpose of generating pseudo random numbers and a seed changing section 43 that outputs instructions to change the seeds that are generated in the seed section 42 at irregular intervals.

In the cryptographic processing unit shown in FIG. 7B, the period of the pseudo random numbers can be changed by providing the seed section 42 and the seed changing section 43, making it hard to decipher the encrypted data. The action by which plain text is encrypted using the exclusive logical sum generator 40 and the pseudo random number generator 41 is the same as in the case shown in FIG. 7A.

Now let us explain the method of changing the period of the pseudo random numbers. In a case in which the pseudo random number generator is realized by a hardware circuit, the period of the pseudo random number generator is determined by, for example, changing the number of stages and the wiring in the linear feedback shift register system that generates the pseudo random numbers.

An example of this is shown in FIG. 8. FIG. 8 shows a case in which one embodiment of a pseudo random number generator is realized by a hardware circuit. In FIG. 8, **44** is a shift register, **45** is a path control section, s0 to s12 and sa to sl are switches for path connection, x1 to x12 are exclusive logical sum circuits and r1 to r13 are bit elements of the shift register **44**. In the circuit shown in FIG. 8, the signal generated by the path control section **45** is used, and the period of the pseudo random numbers is changed by controlling the feedback of r1 to r13 in the shift register **44**, by controlling the connection and disconnection of the paths by means of the switches s0 to s12 and the switches sa to sl.

Now, let us consider the realization of a pseudo random number generator that generates a 3-stage M series. A primitive polynomial that generates a 3-stage M series is x^3+x+1; the hardware configuration is as shown in FIG. 9. In FIG. 9, **44** is a shift register and **46** is an exclusive logical sum circuit. Consequently, in the pseudo random number generator shown in FIG. 8, in order to realize the configuration shown in FIG. 9, the switch s2 and the switch sb are set to ON, and the other switches are set to OFF.

Primitive polynomials that generate an n-stage M series and their periods are given below.

[number of stages n]	[primitive polynomial]	[period]
2	$x^2 + x + 1$	3
3	$x^3 + x + 1$	7
4	$x^4 + x + 1$	15
5	$x^5 + x^2 + 1$	31
6	$x^6 + x + 1$	63
7	$x^7 + x^3 + 1$	127
8	$x^8 + x^4 + x^3 + x^2 + 1$	255
9	$x^9 + x^4 + 1$	511
10	$x^{10} + x^3 + 1$	1023
11	$x^{11} + x^2 + 1$	2047
12	$x^{12} + x^6 + x^4 + x + 1$	4055

For example, in order to realize a 6-stage pseudo random number generator, it is sufficient to feed back the sum of r6 and r1 shown in FIG. 8 to r6, so it is sufficient to set switch s5 and switch se to ON.

Several examples of pseudo random number generators obtained as combinations of pseudo random number generators are shown in FIG. 10.

In the configuration shown in FIG. 10A, the output of the pseudo random number generator shown in FIG. 8 is used as is as pseudo random numbers. In the configuration shown in FIG. 10B, the 2 outputs of the pseudo random number generator **41***a* and the pseudo random number generator **41***b* are input to the exclusive logical sum circuit **47**, and the output of that exclusive logical sum circuit **47** is used as the pseudo random numbers. In this case, suppose for example that the initial seeds set in the pseudo random number generator **41***a* and the pseudo random number generator **41***b* are different from one another. In the configuration shown in FIG. 10C, the 3 pseudo random number generators **41***c*, **41***d* and **41***e* and the switch **48** are used; the outputs from the 2 pseudo random number generators **41***c* and **41***d* are input to the switch **48**. The output of the pseudo random number generator **41***e* is used to control the switch **48** and select the output of either the pseudo random number generator **41***c* or the pseudo random number generator **41***d*. Then the output of the switch **48** is used as the pseudo random numbers.

In the trusted agent of this embodiment, there is a software program to realize the action described above, and pseudo random numbers are generated by executing that program.

The trusted agents shown in FIG. 5 and FIG. 6 have a plurality of cryptographic processing units; it is possible to, for example, use the random number generation systems shown in FIGS. 10A to 10C as the pseudo random number generation sources in the first, second and third cryptographic processing units, respectively.

FIG. 11 is a flow chart that shows the action of an encryption method selection control unit. Here we explain the action of the encryption method selection control unit **25** in FIG. 5.

In step S1, an initial seed is created based on the time, date, day of the week, etc. shown by the internal clock in the workstation **20**. This initial seed is set inside the encryption method selection control unit **25**. In step S2, a pseudo random number generator is used to generate pseudo random numbers from the initial seed created in step S1. In step S3, the encryption method is selected based on the pseudo random numbers generated in Step S2. In step S4, information that identifies the encryption method selected in step S3 is transferred to the encryption method selection units **24** and **34**.

In step S5, the timing with which the encryption method is switched is determined. This switching timing will be explained in more detail below; it is expressed in terms of a parameter such as number of packets or time. In step S6, whether or not the cryptographic processing sequence has reached the time for changing the encryption method is monitored. When the cryptographic processing sequence reaches the time for switching the encryption method, the pseudo random number that was generated immediately preceding that time is set as the seed in step S7, and then the procedure returns to step S2. After that, steps S2 to S7 are repeated.

By means of the processing described above, the encryption method is selected according to the pseudo random number; the encryption method is then repeatedly switched according to the timing determined by the pseudo random numbers.

The method of selecting the encryption method in step S3 and the method of determining the switching timing in step S5 are, for example, as follows. If 64-bit long type pseudo random numbers are used, the range of values obtained by sampling the pseudo random numbers is $-9.223372035\times10^{18}$ to $+9.223372035\times10^{18}$. Consequently, in, for example, a case in which there are 10 encryption methods, values from 1 to 10 are obtained from the pseudo random numbers by taking:

$$\text{selected number}=\text{random}/10^{18}+1$$

Here "random" is a pseudo random number generated by the pseudo random number generator. If there are 5 encryption methods, then values from 1 to 5 are obtained from the pseudo random numbers by taking:

$$\text{selected number}=(\text{random}/10^{18})/2+1$$

If, for example, the number of packets is used to determine the switching timing, then, in a procedure similar to that used to select the number of the encryption method,

$$\text{number of packets}=\text{random}/10^{17}+1$$

This gives a value from 1 to 92 based on the pseudo random number.

Supposing, for example, that "3" has been obtained as the selected number of the encryption procedure in step S3, and that "13" has been obtained as the number of packets in step S5. In this case, at the sending side, when 13 packets in which data encrypted using the third cryptographic processing unit are stored have been sent, another cryptographic processing unit number is selected. Then if "2" is obtained as the selected number in step S3, data encrypted using the second cryptographic processing unit are output until the next switching time. Likewise, at the receiving side, when 13 packets in which encrypted data are stored have been deciphered using the third cryptographic processing unit, another cryptographic processing unit number (here, "2") is selected. Then, received packets are deciphered using the second cryptographic processing unit until the next switching time.

In the case of pseudo random numbers, as opposed to true random numbers, once the initial seed and the generation algorithm are determined, the pseudo random numbers that will be obtained from that generation algorithm are uniquely determined. In the configuration shown in FIG. 6, this property of pseudo random numbers is used. That is to say, since the trusted agents 22 and 32 have pseudo random number generators having the same algorithms, as described above, if the same values are set as initial seeds, after that the encryption method will be switched with the same timing in the trusted agents 22 and 32.

As the method of setting the initial seed, after the same value is set in the trusted agents 22 and 32 in the workstation 20, the trusted agent 32 is transferred to the workstation 30. Or, alternatively, the configuration can be such that a command to generate the initial seed is inserted into the trusted agents 22 and 32, and the trusted agents 22 and 32 then generate their initial seeds independently. In this case, if for example the command is one that generates the initial seed in accordance with "today's date" and "the present time", then, as long as the clocks in the workstations 20 and 30 are functioning correctly, identical random numbers will be generated in the trusted agents 22 and 32, and the same encryption methods will be selected.

Next, let us explain the sequence when data are sent and received between application programs, referring to FIGS. 12 and 13. Here, we consider the case in which data are transmitted from the application program 21 in the workstation 20 to the application program 31 in the workstation 30.

As shown in FIG. 12A, the data from application program 21 are segmented for the purpose of storage in packets. Here, as one example we assume that UDP (User Datagram Protocol) is used as the data transfer protocol. Next, data are encrypted by the specified method, one segment at a time. A sequence number is assigned to each data segment. The sequence numbers are used so that cryptographic synchronization can be established between the sending side and the receiving side even if a packet should be lost. That is to say, the UDP protocol is appropriate when data requiring real time processing such as audio data and video data are transmitted, but since it does not have a resending function, if a packet is lost in transmission it will become impossible to reproduce the data on the receiving side. For this reason, a sequence number is assigned to each data segment, so that the receiving side can detect the loss of packets and reproduce the data correctly.

After that, a header is added and sent to the workstation 30. An example of a packet configuration is shown in FIG. 12B. The sequence numbers and the header are not encrypted.

In the processing described above, the trusted agent 22 does the encryption processing and the processing to assign sequence numbers. It is possible to expand the functions of the trusted agent 22 so that all of the processing shown in FIG. 12A is executed by the trusted agent 22.

When the workstation 30 receives a packet, whether or not a packet has been lost in transmission is judged from its sequence number. If no loss is detected, the encrypted data section is extracted and the data are decrypted. Then the decrypted data are assembled and transferred to the application program 31.

In the processing described above, the trusted agent 32 performs the processing to check the sequence numbers and the decryption processing. It is possible to expand the functions of the trusted agent 32 so that the trusted agent 32 executes all of the processing shown in FIG. 13.

FIG. 14 is a diagram to explain the method of establishing cryptographic synchronization. In encrypted communication using pseudo random numbers, when packets are encrypted using pseudo random numbers on the sending side (the encryption side), it is necessary to use the same pseudo random numbers as the pseudo random numbers used on the sending side when those packets are decrypted on the receiving side (the decryption side). The trusted agents 22 and 32 generate the same pseudo random numbers in the same sequence with the same timing, and execute encryption and decryption processing in their respective sequences. This establishes cryptographic synchronization.

If a packet has been lost in transmission, then, as shown in FIG. 14A, which packet has been lost is detected on the decryption side, and the decryption processing using the pseudo random number corresponding to the packet that was lost is skipped. In the example shown in FIG. 14A, packet 3 has been lost; on the decryption side, random(3) is not used, but instead decryption processing using random(4) is performed with respect to packet 4.

If the order of packets becomes interchanged during transmission, then, as shown in FIG. 14B, after packet 1 is decrypted, if packet 3 is received when packet 2 should be received, the decryption processing using random(2) is skipped. Next, packet 2 is received when packet 3 normally would have been received, so the decryption processing using random(3) is skipped. After that, if packet 4 is received when packet 4 should be received, from this time decryption processing using random(4) is carried out normally.

Thus, the order of received packets is monitored on the decryption side; when loss or interchange of order occurs, synchronization of encryption processing and decryption processing is maintained by skipping decryption processing. This synchronization processing is carried out also in case the first packet is lost.

In the system shown in FIG. 5 or FIG. 6, in order to make it difficult to decipher the encrypted data, the encryption method was changed at regular or irregular intervals. In an encryption method in which use of pseudo random numbers is adopted, it is possible to make the encrypted data difficult to decipher by changing the seed used to generate those pseudo random numbers at regular or irregular intervals.

FIG. 15 shows an example of the configuration of an encrypted communication system having the capability to change the seed used to generate pseudo random numbers. In FIG. 15, the workstations 50 and 54 correspond to the server 10 and the client 15, respectively, in FIG. 1. The application programs 51 and 55 correspond to the application programs 13 and 16, respectively, in FIG. 1. The trusted agents 52 and 56 correspond to the trusted agents 14 and 17, respectively, in FIG. 1.

The trusted agent 52 has an application interface unit 53, and, as were explained referring to FIG. 7B, an exclusive

logical sum generator **40**, a pseudo random number generator **41**, a seed section **42** and a seed generating section (seed changing section) **43**. The trusted agent **56** has an application interface unit **57**, and an exclusive logical sum generator **40'**, a pseudo random number generator **41'** and a seed section **42'**. The exclusive logical sum generator **40**, the pseudo random number generator **41** and the seed section **42**, and the exclusive logical sum generator **40'**, the pseudo random number generator **41'** and the seed section **42'**, are respectively the same type of units.

The action of the encrypted communication system shown in FIG. **15** is as follows. First, the trusted agent **56** that is described in mobile code is transferred from the workstation **50** to the workstation **54**. Next, the seed generating section **43** creates 1 seed and transfers that seed to the seed sections **42** and **42'**, respectively. At this time, a encrypted communication path between the trusted agents **52** and **56** is established.

The seed sections **42** and **42'** input the seeds that they have received to the pseudo random number generators **41** and **41'**, respectively. That is to say, the seeds input to the pseudo random number generators **41** and **41'** are the same as one another. The pseudo random number generators **41** and **41'** generate pseudo random numbers in accordance with the respective received seeds and input them to the exclusive logical sum generators **40** and **40'**. The pseudo random numbers generated in the two units at this time are the same as one another. After that, the seed generating section **43** generates new seeds at regular or irregular intervals in accordance with the specified algorithm and transfers them to the seed sections **42** and **42'**. Consequently, the same pseudo random numbers are generated in the trusted agents **52** and **56**.

Data from the application program **51** are sent to the exclusive logical sum generator **40** via the application interface unit **53**. There the data are encrypted using the pseudo random numbers generated by the pseudo random number generator **41**. The encrypted data are sent to the workstation **54** via the Internet **58**. The data received by the workstation **54** are decrypted in accordance with the pseudo random numbers generated by the pseudo random number generator **41'** in the exclusive logical sum generator **40'**. Then those decrypted data are transferred to the application program **55** via the application interface unit **57**.

In the encryption/decryption processing described above, the action of generating the pseudo random numbers is mutually synchronized in the trusted agents **52** and **56**, so that data encrypted in the trusted agent **52** are decrypted in the trusted agent **56**.

FIG. **16** shows an example of configuration of another embodiment of this invention. In the system shown in FIG. **16**, the trusted agent **52** does not have a seed generating section **43**; seeds are generated in a seed server **59** connected to the Internet **58**. The seed server **59** has functions equivalent to those of the seed generating section **43** in FIG. **15**; new seeds are generated at regular or irregular intervals and transferred to the seed sections **42** and **42'**.

The action of this system is as follows. First, the trusted agent **56** that is described in mobile code is transferred from the workstation **50** to the workstation **54**. Next, the seed section **42** of the workstation **50** requests the seed server **59** for a seed that is needed for encrypted communication. As this time, the trusted agent **52** notify the seed server **59** of the corresponding terminal of the encrypted communication (here, the workstation **54**). The seed server **59** generates a seed in accordance with this request, and transfers the generated seed to the seed sections **42** and **42'**. This secures an encrypted communication path. The seed server **59** subsequently generates new seeds at regular or irregular intervals and transfers them to the seed sections **42** and **42'**. Other action is the same as that described in FIG. **15**.

FIG. **17** shows an example of the configuration of another embodiment of this invention. In the system shown in FIG. **17**, the trusted agents **52** and **56** have the seed generating sections **43** and **43'**, respectively.

The seed generating sections **43** and **43'** have the same functions as one another. In addition, the actions of the seed generating sections **43** and **43'** are synchronized with each other. That is to say, the same initial values are set in the seed generating sections **43** and **43'**, and subsequently they output the same seeds in sequence. The synchronization between the seed generating sections **43** and **43'** is basically the same as the synchronization between the encryption method selection control units **25** and **39** shown in FIG. **6**.

The action of the system shown in FIG. **17** is as follows. First, the trusted agent **56** that is described in mobile code is transferred from the workstation **50** to the workstation **54**. Next, the seeds generated by the seed generating sections **43** and **43'** are transferred to the seed sections **42** and **42'**, respectively, thus securing an encrypted communication path. At this time, the seed generating sections **43** and **43'** output the same seeds in the same order. Other actions are as explained with reference to FIG. **15**.

FIG. **18** is a flow chart that explains the action of a seed generating section or seed server. This processing is basically the same as that in the flow chart in FIG. **11**, which selects the encryption method.

The initial seed is set in step **S11**. The method of setting the initial seed is as was explained with reference to FIG. **11**. In step S12, pseudo random numbers are generated using the pseudo random number generator based on that initial seed. In steps **S13** and **S14**, the generated random numbers are sent to the seed section as appropriate seeds. In step **S15**, the timing at which the seed is changed is determined. This change timing is shown by, for example, a parameter such as number of packets or time. In step **S16**, whether or not the time has reached the seed changing timing is monitored. When the timing to change the seed is reached, in step **S17** the immediately preceding generated pseudo random number is set as the new seed, and the procedure returns to step **S12**. After that, steps **S12** to **S17** are repeated. The seed is changed at irregular intervals according to the processing described above.

In the system shown in FIG. **15**, the seed generating section **43** executes the processing described above. In the system shown in FIG. **16**, the seed server **59** executes the processing described above. In the system shown in FIG. **17**, the seed generating sections **43** and **43'** respectively execute the processing described above. In the system shown in FIG. **17**, the exclusive logical sum generator **40**, the pseudo random number generator 41 seed section **42**, and the seed generating section **43**; and the exclusive logical sum generator **40'**, the pseudo random number generator **41'** and seed section **42'**, and the seed generating section **43'** respectively have the same functions as one another, so that by setting the same initial seed in the seed generating sections **43** and **43'**, the same pseudo random numbers are subsequently generated in the same order.

FIG. **19** is a configuration diagram for the case in which the encrypted communication system of this embodiment is matched to the WWW (World Wide Web).

The server side software consists of the WWW server **60**, the permanently resident trusted agent **61**, and the Applet **62** into which cryptographic processing units have been incor-

porated. The Applet **62** is an agent with cryptographic processing. Meanwhile, the client side software is the WWW browser **63**. The trusted agent **61** corresponds to the trusted agent **14** in FIG. **1**. The Applet **62** is described in mobile code and corresponds to the trusted agent **11** in FIG. **1**.

The action of this system is as follows. First, in the client side WWW browser **63**, access to the WWW server **60** is performed; then the Applet **62** into which the cryptographic processing units are incorporated are transferred from the server side to the client side and that Applet **62** is incorporated into the WWW browser **63**. The procedure by which an encrypted communication path is established between the trusted agent **61** and the Applet **62** is, for example, as shown in FIG. **4**.

When the desired data are requested from the WWW server **60** by the WWW browser **63**, the data sent from the WWW server **60** in response to that request are encrypted by the trusted agent **61**, and sent to the client side. On the client side, the cipher text that has been transferred via the encrypted communication path **64** is received by the Applet **62**. The Applet **62** knows a method to decrypt the data that were encrypted by the trusted agent **61**. The Applet **62** decrypts the cipher text received from the WWW server **60**, and transfers those decrypted data to the browsing software of WWW browser **63**.

Thus, data transmitted from the WWW server **60** to the WWW browser **63** are encrypted by the trusted agent **61** before being sent, and then are decrypted and reproduced by the Applet **62**.

FIG. **20** shows an example of the configuration in the case in which the encrypted communication of this invention corresponds to a video transmission system or an audio transmission system. In this example, a trusted agent into which the cryptographic processing units are incorporated (a trusted agent with cryptographic processing) is used in combination with applications for video transmission and audio transmission.

The workstation **70** from which the audio data and the video data are sent consists of the camera **71**, the analogue/digital (A/D) converter **72**, the frame buffer **73**, the microphone **74**, the analogue/digital (A/D) converter **75**, the buffer **76** and the permanently resident type trusted agent **77** that has a video data/audio data encryption function. In addition, it has the trusted agent **78** in which the decryption function corresponding to the encryption processing in the trusted agent **77** is described in mobile code.

The workstation **80** that receives the video data/audio data consists of the trusted agent **78**, into which cryptographic processing units are incorporated, sent from the sending side workstation **70**; the frame buffer **82**; the digital/analogue (D/A) converter **83**; the display **84**; the audio data reception buffer **85**; the digital/analogue (D/A) converter **86** and the speaker **87**.

The action in this system when video data are sent and received is as follows. First, a request to send the trusted agent **78** is sent from the workstation **80** that wants to receive the video data to the sending side workstation **70**. When the sending side workstation **70** receives this send request, it sends the trusted agent **78** that is needed when image data are decrypted to the receiving side workstation **80**. This completes the preparation for data transfer.

The sending side workstation **70** converts the image data taken in from the camera **71** into a digital signal by means of the analogue/digital converter **72** and sends it to the frame buffer **73**. The frame buffer **73** stores the data from the analogue/digital converter **72** to absorb the difference

between the rate at which data are input from the camera **71** and the encryption processing rate in the trusted agent **77**.

Next, the output data from the frame buffer **73** are encrypted by the trusted agent **77** and sent out to the network. In the receiving side workstation **80**, the encrypted image data that were sent are received and decrypted by the trusted agent **78**. The decrypted image data are reconverted to an analogue signal by the digital/analogue converter **83** via the receiving side frame buffer **82** and displayed on the display **84**.

In the system shown in FIG. **20**, the action in the case of transmission of audio data is almost the same as that described above. That is to say, the real time data that are transferred are audio data rather than video data, the microphone **74** replaces the camera **71** as the input section for the data to be transferred, and the speaker **87** replaces the display **84** as the output section. Otherwise the action is basically the same.

FIG. **21** is a configuration diagram for the case in which the encrypted communication of this invention is used in an electronic conferencing system. In the electronic conferencing system of this embodiment, an agent distributing station **90** and a plurality of hosts **91** to **94** are mutually interconnected via a network **95**. The agent distributing station **90** has a user recognition function and distributes agents in response to requests from official users. The network **95** is, for example, a LAN. The multicast communication path **96** is a transmission path for sending and receiving data among the hosts **91** to **94** during an electronic conference. The multicast communication path **96** can be established within the network **95**, or it can be established on other physical lines separate from the network **95**.

A host that participates in an electronic conference requests the agent distributing station **90** to send an agent that is needed for encrypted communication in order to establish an encrypted communication path. That is to say if, for example, the hosts **91** to **94** are participating in an electronic conference, one among those hosts posts a member that is participating in the electronic conference to the agent distributing station **90**. The agent distributing station **90** then sends a trusted agent in which cryptographic processing units are incorporated to the host that made the request. The trusted agents **97** that are distributed to the respective hosts **91** to **94** secure encrypted communication paths among those hosts using the multicast communication path **96**. Subsequently, data relating to the electronic conference are sent and received in encrypted form.

The agent distributing station **90** can be configured so that it also serves the function(s) of the encryption method instruction server and/or the encryption processing unit distribution server described with reference to FIG. **5**, or for example the seed server **59** shown in FIG. **16**.

Next, let us explain the interface between the trusted agent and the application. Here, as shown in FIG. **22A**, we envision a case in which data are sent and received between the information processing unit **10** (the server in FIG. **1**) and the information processing unit **15** (the client in FIG. **1**). In this case, among the settings of the application program **13** in the information processing unit **10**, the information processing unit **15** is specified as the communication partner, and a port through which the application program **16** receives data is specified as the communication port. Similarly, in the settings of the application program **16** of the information processing unit **15**, the information processing unit **10** is specified as the communication partner, and a port through which the application program **13** receives data is specified as the communication port.

In order to perform encrypted communication, as shown in FIG. 22B, when the trusted agents **14** and **17** are used, in the settings of the application program **13** the same unit (the information processing unit **10**) is specified as the communication partner, and a port through which the trusted agent **14** receives data is specified as the communication port. Similarly, in the settings of the application program **17**, the same unit (the information processing unit **15**) is specified as the communication partner, and a port through which the trusted agent **17** receives data is specified as the communication port.

Thus, by changing the settings of, for example, the communication ports, data sent and received between the application programs **13** and **16** are transmitted via the trusted agents **14** and **17**. That is to say, the data sent and received by the application programs **13** and **16** can be encrypted merely by changing settings such as the communication ports, without changing the application programs **13** and **16** themselves.

The proxy (communication routing port) setting is basically changed the same way as the communication partner and communication port described above. That is to say, if there is a function to set the proxy in an application program, the information processing unit in which that application program is installed and a port through which the trusted agent installed in that information processing unit receives data, are set as the proxy.

The API (Application Interface) provided by the trusted agent is used rather than the API provided by the system. In this case, normally it is necessary to recompile after the source program is changed. For example, if there is no trusted agent, the section in which "open( );" appears, while if there is a trusted agent, the section should be changed "openTrusted( );" is changed, and then the source program is recompiled.

It is also possible for a trusted agent of this embodiment to be realized as a kernel module of the operating system (OS), and to be incorporated into the OS as necessary. For example, in FIG. 22B, it is also possible for the trusted agent **14** to be incorporated at kernel level of the OS that is installed in the information processing unit **10**.

As shown in FIG. **3**, a trusted agent has an application interface section and a cryptographic processing section. As shown in FIG. **4**, the cryptographic processing section consists of a sending section and a receiving section. The sending section has a data encryption function, while the receiving section has a cipher text decryption function. In this embodiment, when a trusted agent that is described in mobile code is sent from the server to the client, it is possible to send only the application interface section and the sending section, or only the application interface section and the receiving section.

One application of encryption and sending of data is broadcast communication, such as VOD (Video on Demand). In broadcast communication, the receiving side unit does not need to have a function to encrypt data as a code processing function; it only needs to have a function to decrypt the cipher text that is sent. Consequently, in this case, when a trusted agent is sent to the broadcast communication receiving unit, only the application interface section and the receiving section are sent.

An example of a program of a trusted agent described in mobile code is shown in FIG. 23 to FIG. 29. This program corresponds to the trusted agent **11** in FIG. **1**, and is transferred to the client. This program includes a function to execute the cryptographic processing of image data.

This program is for the purpose of reading files in from a WWW (World Wide Web) server and displaying animated images. It is described in Java (an object-oriented language for Internet use developed by Sun Microsystems). This program also has a function to read bitmap-format image information (T0 to T9.ppm) in from a server 2,048 bytes (b[ ]) at a time and perform applet displays. This program displays 10 image files one after another and then repeats the action. An outline of the display method is as follows. First, a communication path to and from the server is established, and the necessary image files are requested. Next, that communication path is used to receive image files, and images are displayed. Let us now give a more detailed explanation about the program referring to the drawings.

(A) First, the class path is defined.

(B) The variables to be used are determined.

(C) The init function is a function that performs initial settings for the purpose of initiating communication with the server. The name of the server that is connected, the server port number and necessary file names are specified. In addition, the pseudo random number generation specifications are determined.

(D) The makesocket function is used to send a connection request to the server and create a communication path.

(E) The communication path that was created is used to obtain information concerning the image width and height from the server. This information is needed when images are reproduced on the client side.

(F) As makesocket function processing, a connection request is sent to the server and processing to set up a communication path is described.

(G) The sendimagefile function is a function that uses the communication path to send the necessary image file names to the server.

(H) The getimage function is a function that uses the communication path to receive image files from the server and create images.

(I) when there are no more data in the image files, processing ends.

(J) Image data are decrypted 1 byte at a time.

(K) One pixel is created every 4 bytes. One pixel has 4 components: brightness, red, green and blue.

(L) Images are made up of pixels.

(M) Encryption is prescribed.

(N) When the program starts up, this program is executed as a thread. By executing as a thread, it becomes possible to execute a plurality of processings in parallel within one program.

(O) The thread action is prescribed. After a communication path is created by the init function, the following substantive processing is actually executed.

(P) Processing to display 10 image files is performed; then this is repeated.

(Q) The communication path is used to send the necessary image file names to the server. The sendimagefile function is used for this processing.

(R) The communication path is used to receive image files from the server and create images. The getimage function is used.

(S) The created images are displayed.

As explained above, this invention makes encrypted communication possible by sending an agent that incorporates cryptographic processing units to the communication partner with which encrypted communication is to be carried out, or by receiving an agent that incorporates cryptographic processing units from that partner. For this reason, it is possible to avoid publicizing the encryption method; and, by using agents, the encryption method can be changed at regular or irregular intervals and the parameters needed in

encryption can be changed to make it difficult to decipher the encrypted data. Consequently, a strong encryption method is obtained, having a light overhead that is suitable for real time communication.

This invention is not limited to a cryptosystem but can be widely applied to encode/decode (modulation/demodulation) systems. In this case, an agent including a program for encode/decode (modulation/demodulation) processing described in mobile code is transmitted prior to data transmission.

What is claimed is:

1. An encryption communication method for transmitting encrypted data between a first terminal and a second terminal, comprising:

transmitting, from the first terminal in which a first agent is installed, the first agent including a program for cryptographic processing, a second agent having a function identical to a function of the first agent, to the second terminal;

performing encrypted communication between the first agent and the second agent; and

independently and synchronously changing a parameter needed for the encrypted communication between the first and second agents while the encrypted communication is being performed.

2. An encryption communication method for transmitting encrypted data between first and second terminals, comprising:

transmitting to the second terminal from the first terminal in which a first agent is installed, a second agent, the first and second agents each having identical functions and each including a plurality of cryptographic processing units;

performing encrypted communication between the first and second agents; and

synchronously changing the cryptographic processing units to be used between the first and second agents while the encrypted communication is being performed.

3. An encryption communication method for transmitting encrypted data between a first terminal and a second terminal, comprising:

transmitting to the second terminal from the first terminal in which a first agent is installed, a second agent, each of the first and second agents including a plurality of cryptographic processing units;

performing encrypted communication between the first and second agents;

instructing which cryptographic processing unit is to be used from an encryption method selection server to each of the first and second agents; and

synchronously changing at each of the first and second agents the cryptographic processing units to be used in accordance with said instructing by the encryption method selection server.

4. An encryption communication method for transmitting encrypted data between a first terminal and a second terminal, comprising:

transmitting to the second terminal from the first terminal in which a first agent is installed, a second agent, each of the first and second agents having an identical function for determining the cryptographic processing unit to be used;

setting an identical initial value in each of the first and second agents;

determining a cryptographic processing unit to be used according to the initial value at each of the first and second agents;

performing encrypted communication between the first and second agents; and

changing the cryptographic processing units according to said determining at each of the first and second agents.

5. The encryption communication method according to claim 1,

wherein the programs for cryptographic processing included in the first and second agents use a pseudo random number.

6. The encryption communication method according to claim 5, further comprising the steps of:

creating a seed for the pseudo random number in the first terminal;

setting the seed in the first and second agents;

generating the pseudo random number in accordance with the seed set in each of the first and second agents; and

executing the cryptographic processing using the pseudo random number generated in each of the first and second agents.

7. The encryption communication method according to claim 6, further comprising the step of changing the cryptographic processing at regular or irregular intervals.

8. The encryption communication method according to claim 5,

wherein a seed server which generates a seed for the pseudo random number is provided, and

wherein said method further comprises the steps of:

generating a seed for the pseudo random number in the seed server;

setting the seed in the first and second agents;

generating the pseudo random number in accordance with the set seed set in each of the first and second agents; and

executing the cryptographic processing using the pseudo random number generated in each of the first and second agents.

9. The encryption communication method according to claim 2,

wherein each of the first and second agents has a function for creating a seed for a pseudo random number, the functions being the same as one another, and

wherein said method further comprises the steps of:

setting an identical initial value in each of the first and second agents;

creating a seed for a pseudo random number according to the initial value at each of the first and second agents; and

generating a pseudo random number in accordance with the seed and executing cryptographic processing using the seed in the first and second agents respectively.

10. An encryption communication method for transmitting encrypted data among a plurality of terminals, comprising:

distributing agents including a program for cryptographic processing from an agent distributing server to the plurality of terminals;

performing encrypted communication between the distributed agents; and

independently and synchronously changing a parameter needed for the encrypted communication among distributed agents while the encrypted communication is being performed.

11. An encryption communication method for transmitting encrypted data among a plurality of terminals, comprising:

distributing agents from an agent distributing server to the plurality of terminals, each agent including a plurality of cryptographic processing units;

performing encrypted communication between distributed agents; and

independently and synchronously changing a parameter needed for the encrypted communication among the distributed agents while the encrypted communication is being performed.

12. An encryption communication method for transmitting data between a first terminal and a second terminal, comprising:

transmitting an agent including a program for cryptographic processing described in mobile code to the second terminal via a network;

performing encrypted communication between the first terminal in which a program for cryptographic processing is installed and the second terminal using the agent, the program for cryptographic processing in the first and second terminals having an identical function to generate pseudo random numbers; and

synchronously changing a parameter needed for the encrypted communication between the first and second terminals according to the pseudo random numbers independently generated at each of the first and second terminals.

13. At least one storage medium storing at least one program that when executed causes at least one computer to perform cryptographic processing between first and second terminals, comprising:

transmitting to the second terminal from the first terminal in which a first agent is installed, a second agent, the first agent including a program for cryptographic processing and the second agent having a function identical to a function of the first agent;

performing encrypted communication between the first and second agents; and

independently and synchronously changing a parameter needed for the encrypted communication between the first and second agents while the encrypted communication is being performed.

14. At least one storage medium storing at least one program that when executed causes at least one computer to transmit encrypted data among a plurality of terminals, comprising:

distributing agents including a program for cryptographic processing from an agent distributing server to the plurality of terminals;

performing encrypted communication between distributed agents; and

independently and synchronously changing a parameter needed for the encrypted communication among distributed agents while the encrypted communication is being performed.

15. An encryption communication method for transmitting encrypted data between a first terminal and a second terminal, comprising the steps of:

transmitting from the first terminal in which a first agent is installed, a second agent, the first and second agents providing a plurality of cryptographic processing units and having identical functions, including a function for creating a pseudo random number; and

performing an encryption communication between the first and second agents using the cryptographic processing units, the cryptographic processing units used by the first and second agents being synchronously changed according to the pseudo random numbers which are independently generated in each of the first and second agents.

16. An encrypted communication method for transmitting encrypted data between a first terminal and a second terminal, comprising:

installing in the first terminal a first agent including a program for cryptographic processing;

transmitting the first agent from the first terminal to the second terminal to form a second agent at the second terminal; and

performing encrypted communication between the first and second terminals via the first and second agents while independently and synchronously changing at the first and second terminals an encryption parameter used in the encrypted communication.

17. An encrypted communication method as recited in claim 16, wherein said performing comprises:

encrypting communication between the first and second terminals using an encryption key; and

synchronously changing the encryption key independently in the first and second agents according to a predetermined rule.

18. An encrypted communication method as recited in claim 16,

wherein said first agent includes a plurality of encryption methods

wherein said performing comprises:

synchronously and independently in the first and second agents selecting one of the encryption methods; and

encrypting communication between the first and second terminals using the selected encryption method.

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